PB84-125012

Economic Analysis and Risk Management An Application to Hazardous Wastes

Environmental Law Inst., Washington, DC

Prepared for

Municipal Environmental Research Lab.
Cincinnati, OH

Jan 84

U.S. Department of Commerce
National Technical Information Service
NTIS

PB84-125012

EPA-600/2-84-001
January 1984

ECONOMIC ANALYSIS AND RISK MANAGEMENT: AN APPLICATION TO HAZARDOUS WASTES

by

Environmental Law Institute
Washington, D.C. 20036

EPA Grant No. R805920

Project Officer

Oscar Albrecht
Solid and Hazardous Waste Research Division
Municipal Environmental Research Laboratory
Cincinnati, Ohio 45268

MUNICIPAL ENVIRONMENTAL RESEARCH DIVISION
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

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NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA-600/2-84-001

2.

3. RECIPIENT'S ACCESSION NO.
PB8 4 125012

4. TITLE AND SUBTITLE
ECONOMIC ANALYSIS AND RISK MANAGEMENT: AN APPLICATION TO HAZARDOUS WASTES

5. REPORT DATE
January 1984

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
Robert Anderson, Roger Dower, and Edward Yang

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Environmental Law Institute
1346 Connecticut Ave., NW
Washington, DC 20036

10. PROGRAM ELEMENT NO.
CBRD1A

11. CONTRACT/GRANT NO.
R805920

12. SPONSORING AGENCY NAME AND ADDRESS
Municipal Environmental Research Laboratory--Cin.,OH
Office of Research and Development
U. S. Environmental Protection Agency
Cincinnati, OH 45268

13. TYPE OF REPORT AND PERIOD COVERED
Final 8/78 - 11/81

14. SPONSORING AGENCY CODE
EPA/600/14

15. SUPPLEMENTARY NOTES
Project Officer: Douglas C. Ammon 513/684-7871

16. ABSTRACT

The report evaluates the usefulness of economic analysis in designing effective and efficient hazardous waste regulations. In particular, it examines the applicability of cost/benefit analysis to the specific problems posed by hazardous waste management. The background for the analysis is provided by case studies of regulatory actions on coke oven emissions, saccharin, aflatoxins, and radiation. The report also presents several detailed case studies of past hazardous waste spills. These case studies provided information on how hazardous waste regulations can be analyzed within a cost/benefit framework. The report then selects two specific problems in hazardous waste management to demonstrate qualitatively the application of cost/benefit analysis: uncontrolled dump sites and siting of hazardous waste facilities. It is clear that inadequate data generally will prevent a formal cost/benefit analysis from being undertaken for regulatory programs. However, significant insights can be gained by applying economic analysis to hazardous waste regulations to the extent that available data allow. Such an exercise allows decisionmakers to take a comprehensive and objective view of alternative regulatory policies, revealing cost and benefit relationships and regulatory response priorities.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT
RELEASE TO PUBLIC

19. SECURITY CLASS *(This Report)*
UNCLASSIFIED

20. SECURITY CLASS *(This page)*
UNCLASSIFIED

21. NO. OF PAGES
244

22. PRICE

DISCLAIMER

"Although the information described in this document has been funded wholly or in part by the United States Environmental Protection Agency through EPA Grant No. R805920 to the Environmental Law Institute, it has not been subjected to the Agency's required peer and administrative review and therefore does not necessarily reflect the views of the Agency and no official endorsement should be inferred."

ABSTRACT

Concerned by the environmental, health and safety risks resulting from improperly handled hazardous wastes, Congress enacted the Resource Conservation and Recovery Act and the Comprehensive Environmental Response, Liability and Compensation Act. Regulations developed by the U.S. Environmental Protection Agency under these statutes must be consistent with Executive Order 12291, issued on February 17, 1981, which attempts to reduce unnecessary burdens on regulated industries.

This report evaluates the usefulness of economic analysis in designing effective and efficient hazardous waste regulations. In particular, it examines the applicability of cost/benefit analysis to the specific problems posed by hazardous waste management. The background for the analysis is provided by case studies of regulatory actions on coke oven emissions, saccharin, aflatoxins, and radiation. The report also presents several detailed case studies of past hazardous waste spills. These case studies provided information on how hazardous waste regulations can be analyzed within a cost/benefit framework. The report then selects two specific problems in hazardous waste management to demonstrate qualitatively the application of cost/benefit analysis: uncontrolled dump sites and siting of hazardous waste facilities.

It is clear that inadequate data generally will prevent a formal cost/benefit analysis from being undertaken for regulatory programs. However, significant insights can be gained by applying economic analysis to hazardous waste regulations to the extent that available data allow. Such an exercise allows decisionmakers to take a comprehensive and objective view of alternative regulatory policies, revealing cost and benefit relationships and regulatory response priorities.

This report was submitted in fulfillment of Grant No. R805920010 by the Environmental Law Institute under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period August 1, 1978 to December 31, 1980, and the work was completed on November 10, 1981.

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ACKNOWLEDGMENTS

This report was prepared by the Environmental Law Institute under the direction of Robert Anderson, Roger Dower and Edward Yang. The research was conducted by the staff of the Resources, Air and Water, and Toxic Substances Programs. In particular, the work of Amy Horne and Christine Edmunds deserves special mention. Nuran Giampaolo and Bill Ardinger provided excellent administrative support.

The EPA project officer, from the Solid and Hazardous Waste Research Division, was Oscar Albrecht, who provided critical guidance and advice throughout the project period. We would also like to acknowledge the cooperation of the many firms and government officials who directed us to valuable information and sources for our case studies.

SECTION I

INTRODUCTION

Congress enacted the Resource Conservation and Recovery Act (RCRA) in 1976 and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) in 1980 to control hazardous wastes generated by industrial activities. These statutes, complemented by various state programs, attempt to address the mounting problems stemming from improper management of hazardous wastes, such as groundwater pollution, exposure to toxic wastes, and destruction of natural resources.

Currently, 10-15 percent of the industrial wastes generated annually, equivalent to 30-40 million tons, is considered hazardous.[1] It has been estimated that these figures will increase by as much as three percent per year.[2] Hazardous wastes, as defined under the RCRA regulations, include the residuals of industrial processes which are toxic, corrosive, ignitable, or chemically reactive.[3] Thousands of substances such as pesticides, toxic organic chemicals, inorganics, explosives and flammables fall within this definition. Many of these wastes are not biodegradable and will remain in ecosystems indefinitely. Moreover, the synergistic effects caused by substances acting in combination are largely unknown.[4] In the past, 80-90 percent of these wastes were being disposed of in an unsafe manner,[5] at times causing severe environmental and health damages.[6]

Among the greatest threats posed by the improper management of hazardous wastes is contamination of public water supplies which depend on both groundwater and surface water as potable water sources. In a 1979 survey of 232 hazardous waste disposal sites, forty-five percent had significant groundwater contamination and twenty percent had polluted surface waters.[7] Water source contamination is especially acute in areas of dense population and industrialization. In the past, well closings from groundwater contamination have occurred only after hundreds of thousands of individuals have been potentially exposed.[8] In addition, because groundwater often moves only a few feet per year, contamination in many aquifers may go undetected for years.

To protect the public from the environmental and health risks posed by hazardous wastes, RCRA and CERCLA authorize a complex series of standards, permits, tracking systems, notification requirements, and taxes. When these are finally promulgated they will affect every aspect of the waste stream from generation through ultimate disposal. Although substantial benefits can be expected to result, there will also be significant costs to the private sector in terms of increased production costs, higher prices, plant closures and reduced earnings. A key issue in designing these regulatory programs involves striking an appropriate balance between the positive and negative effects of the regulations, so that the regulations produce net benefits to society as a whole.

This study evaluates the applicability of economic tools to assist allocative decision-making. In particular, cost/benefit analysis is reviewed in light of the specific problems of hazardous waste management. The report begins the process of casting hazardous waste management issues into a cost/benefit framework in an effort to demonstrate its potential to help policymakers more explicitly account for the tradeoffs between the different effects of alternative proposals.

The study begins in Section III with a legal and economic analysis of how resources were allocated to hazardous waste management prior to the RCRA and CERCLA regulations. The effective functioning of common law and free market mechanisms is shown to be inhibited by several factors. The result is less protection from hazardous waste risks than socially optimal providing an economic justification for government action. Given this rationale, Section IV reviews the use of cost/benefit analysis and two variations to guide the development of responsive government programs. Their strengths and weaknesses in drafting environmental, health and safety strategies are illustrated with case studies on coke oven emissions, saccharin, aflatoxins and radiation (found in Appendix A). Although limited in many cases, cost/benefit tools can help achieve a sensible balance in hazardous waste management programs.

Sections V and VI apply the general concepts and considerations highlighted in Section IV to two of the most pressing problems in hazardous waste management: existing uncontrolled dump sites and siting of future hazardous waste facilities. Although the analyses are qualitative and focus only on subsets of the problems, they illustrate the usefulness of cost/benefit tools in organizing information, identifying uncertainties, and highlighting alternatives that may offer least cost solutions to the problems.

SECTION II

SUMMARY

Federal and state governments are increasingly called upon to protect the public from environmental, health and safety risks. Regulatory decisions are often highly constrained by legislative, legal, political, and ethical judgements as well as economic criteria. To assist policymakers in taking economic goals more explicitly into account, economists and others have recommended the use of cost/benefit analysis tools and techniques.[9] This report investigates the applicability of cost/benefit concepts to the problems of regulating environmental, health and safety risks. The purpose is to identify those concepts that are most useful in designing effective government risk management programs. Although the report focuses on hazardous waste management as a particularly complex regulatory issue, several other regulatory cases are reviewed and highlighted in the analysis.

The first step in the analysis is to establish the underlying justification for government intervention in hazardous waste management. It is argued that existing mechanisms are limited in their effectiveness and allocate too few private resources to safe waste disposal. High transaction costs, in terms of informational uncertainty, bargaining costs, enforcement costs and others, act to limit public protection from health and environmental risks. A justification for government intervention to provide a higher level of safety is shown to exist.

Given this economic mandate, cost/benefit analysis and its variants, cost/effectiveness and risk/benefit analysis, were reviewed in terms of their ability to guide decisionmakers towards providing the optimal level of risk protection. In general, it is shown, through examples from actual regulatory actions, that formal cost/benefit analysis is often inappropriate because of several factors. These include: scientific and technological uncertainty; inability to derive monetary values for benefits; and irreversibilities. On the other hand, it is argued that the underlying characteristics of cost/benefit analysis, most notably the effort to identify and quantify, to the extent possible, all positive and negative consequences of regulatory actions, can serve many critically important functions. In particular cost/benefit analysis: 1) identifies the crucial relationships affecting costs and benefits; 2) provides a model for organizing available information on the effects of a proposal; 3) helps identify what is known and what is unknown; 4) helps isolate the strengths and weaknesses of the available data; and 5) can provide an economic ranking of the most relevant alternatives. Cost/benefit analysis provides a way of thinking about a regulatory problem that renders valuable insights and information to policymakers.

The application of cost/benefit concepts is demonstrated, simplisticly and qualitatively, by analyzing two specific problems in hazardous waste management: coping with orphaned sites and ensuring adequate disposal capacity. In the first case, the difficulties in estimating costs and benefits are illustrated by the problems of changing market structure and devising incentives for noncompliance with legislatively mandated reporting and notification requirements of RCRA. This analysis suggests, for example, that positive incentives to induce responsible parties to reveal information on sites and spills might yield more benefits than strict reporting rules as required by CERCLA.

A major problem facing federal and state officials is ensuring adequate hazardous waste disposal capacity in the face of public opposition. The analysis in this report begins by identifying the basic economic transactions that lead to the allocation of siting rights. In this review transaction costs are shown to inhibit trade in the right to site a facility. This analysis suggests alternative federal and state responses including federal efforts to improve the flow of information concerning risks and state programs to facilitate negotiations between developers and communities. Unfortunely, formal application of the economic considerations underlying cost/benefit analysis and its variants to the problem of optimal hazardous waste management must await an expanded and improved data base. Specifically, the analysis presented here is limited by a paucity of information on the characteristics of hazardous waste sites, the risks associated with the constituents of the sites, the costs associated with providing safer sites, and the effectiveness of alternative control technologies. Current government efforts to regulate hazardous waste disposal should provide, over time, a much improved understanding of all these variables. As this information becomes available, cost/benefit tools can and should play an important function in the revision and refinement of these regulations. However, a less rigorous application of cost/benefit concepts can provide immediate guidance to policymakers on the development of sound environmental risk regulatory policy.

SECTION III

A LEGAL/ECONOMIC FRAMEWORK FOR HAZARDOUS WASTE MANAGEMENT

INTRODUCTION

This section explores the rationale for extra-market intervention in hazardous waste management by investigating why market-oriented mechanisms do not provide the appropriate level of safety in hazardous waste management. The decision to investigate more closely the underlying rationale is based on two related presuppositions. First, the problems posed by hazardous wastes and their causes are extremely complex and require some understanding before alternative control mechanisms can be evaluated. Second, mechanisms to induce care in hazardous waste management already exist. If these mechanisms are assumed to work inadequately, then it is crucial to understand the barriers leading to their malfunction; it is towards these barriers that a regulatory scheme should be directed.

The following analysis describes the legal and economic framework within which resources are allocated between disposal of hazardous wastes and protection of the public and the environment from risks associated with disposal activities. The analysis begins with a description of the basic economic framework within which transactions concerning hazardous wastes can take place. The limitations on economic transactions will then be discussed in terms of their interaction with the legal environment which influences hazardous waste management decisions. Following development of the theoretical economical/legal framework, factors such as governmental regulatory programs, imperfections in information concerning the "risk" or uncertainty posed by hazardous wastes, and the costs of transactions will be incorporated into the analysis. It becomes clear that the existing market fails to provide adequate safety, indicating a potential need for federal or state regulatory initiatives. It is the existence of these market breakdowns that will help identify regulatory remedies. By reviewing private market allocation mechanisms and their possible failures, we hope to identify regulatory options that could address such failures and supplement the private market.

ESTABLISHING THE FRAMEWORK

In economics terminology, improper hazardous waste disposal generates an externality. That is, a private disposal firm's decisions may impose costs on individuals whose environment is contaminated by the wastes. To the extent that these costs do not accrue to the firm (are external to the firm's decisions), the private costs of the firm's actions are less than the social costs. This encourages illegal dumping. The divergence of private cost from social cost creates a misallocation of resources; too few resources are devoted to safe disposal activities.

An ideal solution for reducing the hazardous waste disposal externality is to force the victim's costs to be incorporated into the disposer's decision making. In the simple case where an activity on the part of party A imposes an externality on party B and no others, party B can negotiate with party A to reduce the externality or party B can seek damages (compensation) in court. In either case, the need to deal with the expected costs of the externality will become part of party A's decision process and the economically efficient level of the activity in question will result.

Transactions between generators of hazardous wastes and the public will lead to the appropriate level of hazardous waste management. In this solution, additional care in disposal will be undertaken up to the point where the public's marginal willingness to pay (the benefits of proper waste disposal) is equal to the marginal costs of the improvement. This level of care is efficient in that it minimizes the total social costs of disposal including private disposal costs and the costs of damages to health and the environment.

In this ideal framework the transaction ground rules are set by the legal system. In particular, the legal structure defines, through common or statutory law, who has the right or is "entitled" to do something. Within an entitlement structure, the legal system further defines the rules for market transactions by protecting the structure through one of two ways: property rules or liability rules. A property rule permits the removal of an entitlement only if both the "entitled" and "unentitled" parties agree to the terms of a voluntary transaction (e.g., a typical real estate transaction or the case discussed above). In contrast, a liability rule allows the removal of an entitlement as long as the entitled party is compensated by an objectively determined amount (e.g., eminent domain proceedings), which is generally decided by a judge or jury.

For example, if the right to be free from the risk of a hazardous waste disposal lies with the public, a property rule would require that the unentitled party (generators or disposers) attempt to buy or negotiate the rights to dispose the wastes from the public. Alternatively, under a liability rule the generators and waste management industry can proceed to dispose of waste and then compensate the public when harmful effects take place.

It has been established by several authors that if the world could be characterized by perfect information and costless transactions, then it would matter very little where the initial entitlements are set or whether they are protected by property or liability rules.[10] In other words, an optimal, in the sense of efficient, amount of hazardous waste management would result no matter where the entitlements are set or how they are protected.[11]

Generally speaking, American common law recognizes the right to be free from the health and environmental hazards of waste disposal. Depending on a variety of factors, the entitlement structure is protected by a property rule or a liability rule or both; (i.e., the hazardous waste disposal activity is stopped or those injured are compensated). Under common law there are two basic types of nuisances: private nuisance and public nuisance. A private nuisance is the "substantial and unreasonable interference with the use and enjoyment of land" owned by a particular person. Public nuisance is the "unreasonable interference with a right common to the general public."[12] Since a waste site leaking hazardous substances to the surrounding area clearly constitutes an "unreasonable interference" both to the enjoyment and use of one's land and to the public right to be free from health hazards, both private and public nuisance will usually be pertinent in the context of resolving hazardous waste problems. A public nuisance action has two advantages over a private nuisance in that it is neither limited to protecting interests in land nor subject to several equitable defenses.[13] On the other hand, private nuisance obviates potential standing[14] problems and allows all citizens who are adversely affected by hazardous waste sites to bring an action.

In a nuisance action the court balances the rights of the hazardous waste site owner with either the rights of the general public (public nuisance) or the rights of the adversely affected land owner (private nuisance).[15] The factors most important in the balancing include the:

- o Utility of the hazardous waste operation,
- o Cost and availability of suitable control measures and,

- Severity and nature of the harm caused by the hazardous waste operation.

Courts are vested with considerable discretion in the balancing process, but are very apt to enjoin activities which create public health hazards.[16]

A person in control of a hazardous waste site can be held liable or enjoined under a nuisance theory if the harm is intentionally or negligently caused or if the activity is judged to be abnormally dangerous. Many hazardous waste site harms are intentional in the sense that the owner or operator knows he is improperly disposing of the wastes or has been notified that harm is resulting from the activity. Even if the owner or operator did not know or was not notified of the harm, negligence can form the basis of liability in the event that "reasonable care" was not used to prevent possible harm. Liability under nuisance theory can also result in the absence of intention or negligent conduct. If an activity is "abnormally dangerous," the person undertaking that activity is liable for all foreseeable harms that result by the application of strict liability theory.[17] Regardless of whether the nuisance is based on intent, negligence, or strict liability, the interference with the public or private right must be "substantial" in order for the nuisance action to be successful. As common law has developed, almost any health threat would be substantial.

PROBLEMS OF THE FRAMEWORK WHEN APPLIED TO HAZARDOUS WASTES

The framework established above suggests that any allocation of rights and any set of protection rules will lead to market transactions that ensure an efficient allocation of resources. The validity of this conclusion, though, rests on the assumptions of perfect information and costless transactions, the reality of which is questionable. Several pieces of information are necessary for an individual or party to bargain or bring action against a generator or disposer of hazardous waste. Specifically, information is required on the number and location of currently active and abandoned sites and on types of wastes disposed in sites. In the case of before-the-fact negotiations, information is required on the probability of human and environmental exposure to hazardous wastes, expected health or environmental responses to exposure, and the value of the damages resulting from the exposure.

It is often the case, though, that the information requirements cannot be met. Scientific controversy over the health and environmental effects of the myriad of chemicals and compounds often prevents drawing firm conclusions. A notable example, and one that is of legal importance, is the inability to define threshold levels for health effects from many hazardous chemicals found in waste sites. Uncertainty as to what level, if any, of exposure to a toxic compound can be deemed safe complicates the determination of de minimus invasion of the right to be free from adverse effects of hazardous waste activities.

Another example of uncertainty caused by inadequate information concerns the long time period between exposure to some hazardous wastes and the resultant effects. The legal system simply does not adequately handle health and environmental effects subject to latency periods. Many risks stemming from hazardous waste disposal activities do not surface for many years (e.g., when a 30-year-old inactive site begins to leak). Additionally, the period between the exposure to a risk and the manifestation of an injury is often long and transgenerational (e.g., a pregnant mother, residing near a hazardous waste site, gives birth to a child who later develops cancer)and, therefore, difficult to establish.[18]

Imperfect information concerning hazardous wastes directly affects the working of the legal system. Potential plaintiffs (and courts) will often lack the requisite information or knowledge to abate a dangerous hazardous waste disposal activity. The hazards must be obvious, and some manifestation of the hazard (e.g., sickness, deformities, death) must result before the legal system is activated to abate the hazard. Of course, the victims are entitled to be compensated by the legal system for their injuries. However, because of information gaps, the victims do not have the opportunity to bargain in courts for better protection. In effect, the common law entitlements structure favoring the public is transformed, due to information gaps, to one in which the disposers of hazardous wastes are not encouraged to provide sufficient care or share information because damages are hard to prove (i.e., the entitlement is only weakly protected by a liability rule). Of course, after the damage becomes obvious and substantial and after the court action is brought, the entitlements are additionally protected by a property rule. By their very nature though, such rules are retroactive; i.e., the hazardous activity is permitted to continue during the interim, subject only to a liability rule.

In addition, nuisance law requires that the invasion be substantial before an injunction or damages will result. Although almost any health threat is considered to be more than a de minimus invasion, neither the government nor the potential victim may have enough incentive to institute an action in marginal cases, although injuries of this sort may be significant in terms of their aggregate impact on hazardous waste risks.

Although the bulk of the discussion so far has focused on uncertainty as a particularly important type of transaction cost, there are others of potentially equal importance in specific cases. These include search costs, bargaining and decision costs, and policing and enforcement costs.[19] For example, it may be costly to determine who is the appropriate bargaining party in order to arrive at a mutually agreeable solution. Further, it may be difficult to ensure that the terms of the agreement are not violated (e.g. monitoring costs). All of these costs can be translated into costs of uncertainty, yet it is useful to be aware of the different types; the existence of one rather than another will suggest different forms of government action.

The existence of transaction costs associated with allocating hazardous waste safety resources, suggests that the earlier conslusions no longer hold. Bargaining towards optimal allocation levels is inhibited and often does not take place at all. Different entitlements requirements and protection rules will lead to different amounts of safety. The decision on the part of a hazardous waste disposal firm to dump wastes along a roadside rather than in a safely designed facility, imposes costs on individuals whose water supply may become contaminated by the wastes. In reaching a decision on how safely to dispose of their wastes, a firm will select a level where the private costs and benefits, at the margin, are equal. Without bargaining for compensation, the firms private costs (disposal costs plus costs for damages) are less than the true social costs of its action. The result is too little resources, from a social point of view, being devoted to limiting the risks of hazardous waste disposal.

In general, economic theory supports government actions to counter the external effects of production or consumption activities; these actions serve to internalize the external costs. Intervention can take the form of direct regulation, such as command and control, or performance standards, or a broad range of activities that are intended to reduce the transaction costs that inhibit the legal/economic environment. The latter programs might involve shifting the entitlement structure to favor uniformed parties, providing technical and scientific information, or acting as a trading center for bargaining parties. Economic theory also limits the extent and form of government action by requiring that the costs of the intervention be balanced by its benefits. So, for example, a program to reduce the transaction costs associated with uncertainty is justified only if the costs equal (in terms of administrative time, effort and research), at the margin, the benefits (in terms of damages avoided) resulting from increased bargaining or compensation payments forcing increased safety. It is noteworthy that this criteria allows for the possibility of no government action if the transaction costs are so high that no program shows positive net benefits.

CONCLUSION

This section has served several interrelated purposes. First, it provided a brief summary of the legal/economic environment that determines how hazardous wastes will be managed. Second, this review identified transaction costs as the major factor influencing the effectiveness of legal/economic mechanisms for controlling hazardous waste risks. It showed that transaction costs provide the justification and focus for government actions to reduce costs and promote greater safety. Finally, the importance of cost/benefit trade-offs from an economist's perspective was highlighted. The extent and form of government intervention to reduce hazardous waste risks should be based on an accounting of the costs and benefits of the reasonable alternatives. The next section examines in more detail the application of cost/benefit analysis to environment and health and safety regulatory issues, and identifies components of such an analysis that can be usefully applied to policy decisions concerning hazardous wastes.

SECTION IV

THE USE OF COST/BENEFIT ANALYSIS FOR HAZARDOUS WASTE MANAGEMENT

INTRODUCTION

Cost/benefit analysis is an often cited economic tool for guiding the development of effective and efficient government regulatory policy. In general, it is asserted that regulatory strategies based on cost and benefit considerations will improve the allocation of society's resources. The purpose of this section is to assess whether cost/benefit techniques can assist in the formulation of hazardous waste management policy.

This section is divided into three general parts. First, the distinguishing characteristics of cost/benefit analysis and its variations, risk/benefit and cost-effectiveness analysis, are briefly described. Second, several pervasive difficulties in formally applying these techniques to issues of environmental health and safety (EHS) risks are stressed. These problems include: uncertainty over health effects and economic costs, questions of intra- and inter-generational equity, and the proper value of human life. Wherever possible, these issues are illustrated with examples from four federal regulatory actions: the Occupational Health and Safety Administration's (OSHA) coke oven exposure standard, the Food and Drug Administration's (FDA) proposed regulations on saccharin and aflatoxin, and the Environmental Protection Agency's (EPA) regulations on uranium fuel cycle radiation. (The case studies for these regulatory actions appear in Appendix A)

Finally, the concepts and characteristics of cost/benefit techniques are evaluated in light of hazardous waste management problems. It is shown that there are severe limits to the formal application of such tools for regulatory policy design. On the other hand, the section argues that the characteristics and concerns of cost/benefit analysis do form a general framework within which decisions concerning hazardous waste rulemaking can and should be scrutinized. While the use of a cost/benefit perspective will not necessarily lead to more economically efficient decisions, it does provide a clearer picture of the ability of any problem to achieve the desired results.

CHARACTERIZATION OF COST/BENEFIT, RISK/BENEFIT AND COST/EFFECTIVE ANALYSIS

Cost/Benefit Analysis

Cost/benefit analysis is one of the most important perspectives for evaluating proposed public expenditures. Its cornerstone, the principle of economic efficiency, is stated clearly in the Flood Control Act of 1936. This act requires that only those projects for which the "benefits to whomsoever they accrue exceed their costs" shall be submitted for congressional action. Stated in other terms, this principle asserts that projects are considered to be worthwhile only if the benefits of the action are equal to or greater than the costs.

The criterion that benefits must exceed costs applies to entire projects as well as their constituent parts. Thus one must consider both marginal costs and marginal benefits as small changes are made in a project plan and compare these incremental changes with the relevant alternatives. Of course, the margin at which the costs and benefits are defined may vary depending on the relevant policy issue. The usual margin is defined in terms of levels of control stringency; others might include size of firms being included in a program or timing of compliance.

In a cost/benefit analysis, all positive and negative consequences of an action are converted to a common unit of measurement, most often dollars, but conceivably other metrics such as lives saved or environmental quality could be used as well. When applied to the management of environmental, health and safety risks, cost/benefit analysis would require that all the benefits of a regulatory program (the value of reduced health risks, for example) be compared to all the costs (the opportunity costs of resources diverted to the program).

A number of difficulties arise when one attempts to estimate the benefits of programs designed to reduce environmental, health, and safety risks.[20] First, rarely does scientific and technical information permit a full determination of the health and environmental risks posed by various substances or activities. Data on generation of pollutants or hazards, transmission of the substances, levels of exposure, types of receptors exposed, and the relationship between exposure and adverse effects are generally of poor quality, if know at all. Second, even if the precise health and environmental risks were known, one would still need a means of valuing these risks.

Benefits are normally valued by the amount that beneficiaries would be willing to pay to obtain the services that flow from the program. Where these goods and services are bought and sold, market prices can often be used to value the activity (for example, the value of increased crop yields due to an air pollution control program can be estimated from the market price for the crops). Reduced environmental, health, and safety risks present a quite different situation. Because these risks are not traded on markets, corresponding market values do not exist and can only rarely be directly estimated. Furthermore, the beneficiaries frequently are not identifiable individuals. Rather, the benefits typically accrue to larger populations and are best expressed as a reduction in the statistical probability of incurring an adverse health effect.

A valuation procedure for these risks requires one, in essence, to place dollar values on small changes in the probability of such adverse outcomes as cancer, heart disease and ecosystem disruption. In the absence of market transactions, alternative techniques have been suggested and used to arrive at values for risk. For example, although markets do not exist for environmental or health risks, they sometimes may be a component of market transactions--as when wage premiums are paid for risky employment. But relatively few people participate in risky occupations, and these individuals may have preference structures more accepting of risk than has the general population. Some individuals may not accept risky forms of employment even with wage premiums 10 or 20 times as large as those that presently exist. Moreover, many employees are probably largely ignorant of the actual risks inherent in the workplace. Thus, inferences based on market transactions, even where possible, may understate the value of health, safety, and environmental risks to certain (perhaps large) segments of society.

Another common alternative, direct questioning of individuals about their preferences for risk, encounters difficulty as well. Individuals often have little or no experience in acquiring and consuming the commodity, "reduction in risk to life." And how many individuals can evaluate the significance os small changes in probabilities for the adverse outcomes? in fact, experimental evidence of human behavior indicates that individuals underrate, in an expected value sense, the losses from high-probability, low-cost outcomes, but overrate very low probability and highly adverse outcomes.[21]

Although valuing health effects involves difficult questions of the appropriate methodology and assumptions, the underlying philosophy of cost/benefit analysis, that the marginal costs and benefits of a program should be equated, forms a guiding principle for hazardous waste management. So, for example, if an additional unit of risk reduction, through regulation of hazardous waste sites, is valued at $10 and it costs only $8 to produce that reduction in risk, resources should be devoted to that program. To the extent that exact valuation of the risks cannot be undertaken, variants of cost/benefit analysis, discussed below, may be implemented that at least approximate the solution that would be ideally obtained through a more rigorous framework.

Risk/Benefit Analysis

Risk/benefit analysis starts from the same initial point as cost/benefit analysis in evaluating all consequences of an action. However, risk/benefit analysis stops short of a total aggregation of consequences, choosing instead to divide consequences into two or more categories such as risks to health, safety and the environment on one hand and economic benefits on the other hand. These two categories of consequences would then compete against one another in the decision process. In general, it is not necessary to place a value on the risks imposed.

As noted, in risk/benefit analysis one seeks to quantify all of the consequences of a regulatory decision, trading one group of consequences off against a second (or third) group of consequences. One feature is that the final decision on how to trade risks off against benefits is not resolved explicitly. In this mode of analysis, certain alternatives can be shown to dominate others, thereby narrowing the range of decisions to be considered. However, one usually cannot eliminate alternatives by simply comparing the ratio of benefits to risks since choices based on ratios are appropriate only when projects can be extended in scale. Some of these points are illustrated in Figure 1.

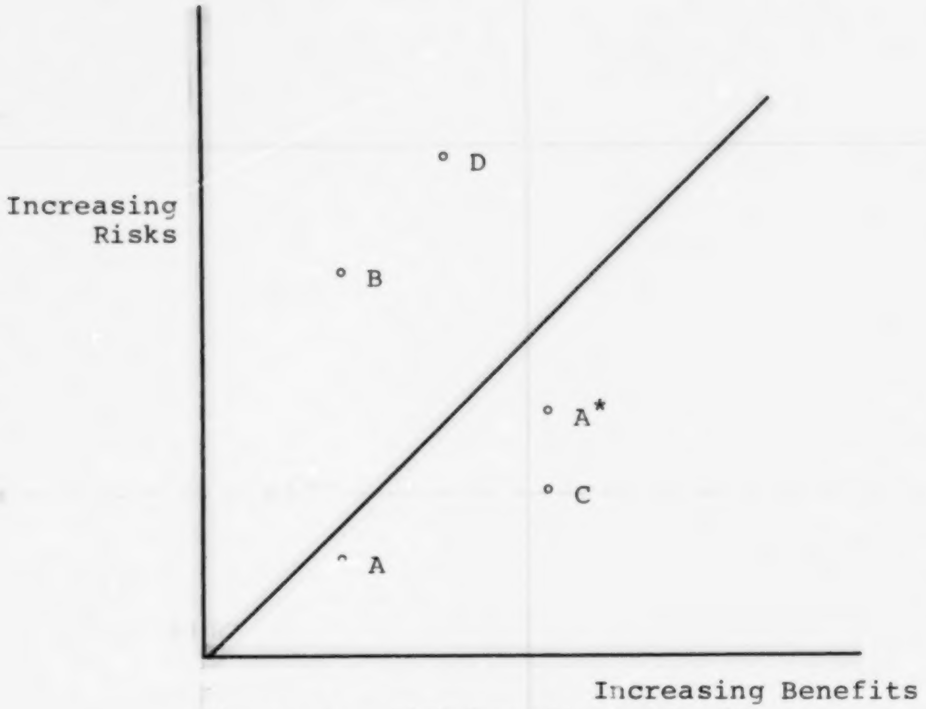

Figure 1. Risk/benefit tradeoffs.

Alternative A is preferred to B because it offers less risk for the same level of benefits; likewise C is preferred to B. Alternative A is preferred to D only if A can be extended in scale, doubling to A* where it now offers greater benefits and less risk than D. If scale expansion is not possible, one cannot choose easily between A and D.

Cost/Effectiveness Analysis

Cost/effectiveness analysis is a generalized version of which risk/benefit analysis is the special case. Here, the consequences are aggregated into categories but there is no attempt to compare the two. Cost/effectiveness analysis sets the constraint that for a given level of control (or risk reduction) the costs of achieving that goal are minimized. Alternatively, this can be expressed as maximizing the amount of control (or risk reduction) for a given level of expenditure. It is possible, therefore, that costs could exceed benefits in a cost effective solution. As in the case of risk/benefit analysis, cost/effectiveness techniques do not strictly require the valuation of risk reduction. Instead, cost/effectiveness analysis requires only the measurement of the amount by which risks are reduced.

This approach can be extremely useful in choosing among alternative regulatory approaches or controls to meet a set standard for emission control or some other environmental parameter. For example, when the Occupational Safety and Health Administration (OSHA) promulgated the cotton dust and coke oven emission standards, which were primarily technology based regulations, questions were raised as to whether other types of controls, such as personal protection devices, would provide the same level of risk reduction at a significantly lower cost.

Other Approaches

One criterion that provides a tempting alternative to cost/benefit approaches is "minimax" regret under which decisionmakers minimize the chance that the worst thing can happen. This approach provides a comfortable rationale for the decisionmaker who wants to protect against a major failure but is not concerned about a steady stream of small, possibly unpublicized losses as a consequence. For example, by mandating extensive testing for new drugs, an agency may protect against a very harmful drug reaching the market; however, the same strict testing requirements may also block the approval of many other beneficial new drugs if their total safety cannot be demonstrated conclusively. Such decisions would likely meet with opposition from a fully informed public, for if the worst outcome is highly improbable, it is likely that most individuals would not seek such expensive insurance.

Another alternative to cost/benefit analysis involves public views on the value of risk reduction. In a "demand revealing process" information on the characteristics of a specific regulatory program (such as level of control, who is affected, costs, etc.) is placed within the framework of a political decision model that predicts whether the public would vote to undertake the particular program. An interesting aspect of the model is that voter response is not a function of net benefits but of the ratio of costs to benefits. While the required socio-economic survey and benefit information for this technique may be costly to obtain, it represents an intriguing alternative to the other more traditional approaches.

Yet another approach to risk management is to set a maximum acceptable level of risk for individual activities. For example, an agency could argue, as some do, that risks of death below certain stated levels are acceptable. A maximum acceptable risk level currently gaining some adherents is a one in 10,000 chance of death from exposure to the hazard. The problem with the approach is obvious--there is no comparison with the costs of creating marginal changes in the risk of death. While one may be willing to give up a food colorant that produces such a risk of death in strawberry sodas, one may not be willing to forego travel by jet airplane because of such an incremental radiation risk.

This introductory discussion suggests that cost/benefit analysis and its variants can provide valuable insights into the manner in which society allocates resources for the reduction of environmental, health and safety risks. For example, hazardous waste managers reviewing inactive disposal sites often face situations where there is a small probability that a serious pollution incident could result (e.g., a Love Canal) and a large probability that the wastes will remain safely contained. If waste management practices are all geared to prevent the next Love Canal (a "minimax" approach), a serious misallocation of resources could result. That is, the health, safety and environmental improvement purchased to guard against future Love Canals may provide these improvements at significantly greater cost than if resources were devoted to improvements in other areas. Such cost/effectiveness considerations are dramatized in Table 1 which provides estimates of the cost per life saved in several environmental, health and safety programs supported, operated or mandated by the government.

The very large differences in cost per life saved indicate the great potential for using resources more effectively. Were OSHA to abandon its plans to protect so fully against occupational exposures to coke oven emissions and acrylonitrile and permit some of the money to be spent in areas where lives are saved more cheaply, hundreds of additional lives could be saved. For example, if $10 million could be diverted from the protection of coke oven workers (where the average cost per life saved may be as high as $5 million) to the elimination of railroad crossings (where the estimated cost per life saved is $100,000), the loss of two coke oven workers' lives might save the lives of 100 motorists.

TABLE 1. ESTIMATES OF COST PER LIFE SAVED

Program	Cost per life saved (1000$)
Medical expenditure	
Kidney transplant	$ 72.0
Dialysis in hospital	270.0
Dialysis in home	99.0
Traffic safety	
Recommended for cost/benefit analysis by the National Safety Council	37.5
Estimate for elimination of all railroad grade crossings	100.0
Military policies	
Instructions to pilors on when to crash-land airplanes	270.0
Decision to produce a special ejector seat in a jet plane	4,500.0
Mandated by regulation	
Coke oven emissions standard, OSHA	4,500.0-158,000.0
Proposed lawn mower safety standards, CPSC	240.0-1,920.0
Proposed standard for occupational exposure to acrylonitrile, OSHA	1,963.0-649,976.0

Source: Reducing Risk to Life, Martin J. Bailey, American Enterprise Institute, 1979.

Though the usefulness of cost/benefit type analyses may be obvious, several factors, some of which have already been mentioned, act in concert to thwart the practical application of these tools. The next portion of this chapter will discuss some of the major obstacles to performing a thorough cost/benefit analysis of environmental, health, and safety risk reduction regulatory programs.

PROBLEMS IN APPLYING COST/BENEFIT TYPE APPROACHES

The case has been argued that a careful consideration of the costs and benefits of proposed governmental actions may lead to better policy decisions. It is now appropriate to reflect upon some of the difficulties with the approach. In reviewing these problem areas it is important to recognize that decision mechanisms other than cost/benefit analysis are also plagued with serious methodological problems. Thus despite these shortcomings, cost/benefit analyses are at least a useful supplement to and even a desirable criterion for regulatory decision-making.

Scientific and Technical Uncertainty

The area that has been singled out by the EPA Science Advisory Board as most damaging to the cost/benefit mode of analysis for health, safety and environmental regulations is the paucity of hard scientific evidence on most of the substances the EPA will be regulating. The Science Advisory Board (which includes a number of prominent environmental and resource economists, political scientists, and natural scientists) concluded that the poor quality of much of the scientific information on releases, exposures, and ultimate human health impacts of many environmental pollutants renders the direct application of cost/benefit analysis to many of the regulatory decisions that EPA will be facing virtually useless.

The weakness of much scientific information regarding pollution and the environment is clearly illustrated by the controversy over evidence on the carcinogenic properties of saccharin. At the time of the proposed rules, a series of epidemiological and animal (rat) studies on saccharin were available to FDA. The epidemiological studies were inconclusive as to whether saccharin caused an increased risk of bladder cancer among the consuming population. The animal studies, on the other hand, showed, in general, a statistically significant increase in bladder tumors among second generation male rats. All of these studies were plagued by general methodological concerns (for example, the ability of epidemiological studies to detect low level health risks) as well as questions more applicable to specific tests (such as the purity of saccharin used).

In the face of conflicting and uncertain evidence, FDA chose to rely heavily on the results of a two-generational animal study in concluding that saccharin is carcinogenic. Even then, questions were raised concerning how these results could be used to estimate the decrease in the risk of developing bladder cancer among consumers that could be attributed to the proposed regulation. Different techniques for extrapolating results from rats to humans as well as different techniques for extrapolating the high doses fed to rats to the low doses consumed by humans lead to remarkably divergent estimates of risk reduction. Although FDA finally estimated that 0 to 4 fewer persons per 100,000 would develop bladder cancer if saccharin were banned, the health benefits of this regulation are highly uncertain and depend on several significant assumptions.

Even if a fairly sound relationship between exposure to a substance and the resulting health effects can be established, other variables can introduce significant uncertainties in estimating the reduction in risk due to a regulatory program. One common problem is providing an accurate measurement of individual exposures to different levels of the hazard. During the rulemaking process on OSHA's coke oven emission standard a wide range of risk reduction estimates were provided by various parties. A large portion of the differences were due to alternative assumptions concerning the number of coke oven workers at risk. Particularly troublesome were differences between estimates of the number of potential future workers who would benefit from the standard. Estimation of the population at risk obviously becomes more intractable as one moves from work place to ambient environmental exposures.

Another aspect of scientific uncertainty often encountered in rulemaking processes is multiple health effects. Again, the coke oven standard study highlights this problem. All of the risk reduction estimates submitted on coke ovens referred only to mortality from lung cancer. No estimates were provided for reductions in morbidity or in the incidence of other types of cancer and illnesses associated with exposure to coke oven emissions. This omission occurred because the primary focus of the major epidemiological studies was on lung cancer mortality; no such quantitative evidence was available for the other health effects. A cost/benefit analysis of the coke oven standard based on lung cancer mortality alone might suggest a less stringent standard, whereas inclusion of other health effects might lead to the opposite conclusion.

With such uncertainty commonly surrounding estimation of the benefits of controlling a substance for which extensive testing has been done, the outlook for benefit estimation on substances for which little evidence is available may appear bleak. Such a conclusion would cast considerable doubt on the wisdom of pursuing a benefit analysis of future regulatory actions. In many cases this pessimism is warranted, but for others the available evidence may be more than adequate to support regulatory action. Corrosive water is a good illustration of this point. While the adverse health impacts of corrosive water are open to speculation and doubt, the damages to municipal water supply systems are well known. Cost/benefit analysis shows that treatment of drinking water to protect supply systems is justified and any health benefits can be viewed as an unquantified benefit. While the actual level of corrosivity reduction that is chosen may be somewhat less than ideal, the regulatory decision will at a minimum be guaranteed to produce net benefits to society. If decisionmakers can be certain of producing positive net benefits, they can act with much greater confidence. However, at the present time allegations are frequently heard that the benefits of many of the nation's health, safety and environmental regulations are outweighed by the costs of achieving compliance.

Even when the scientific data base does not permit accurate estimation of human health effects there exist a number of methods, some of which have already been mentioned in reference to saccharin, for making informed guesses about the health effects. One the more appealing is the use of subjective probability assessments provided by experts on the issue. Recently, EPA utilized this type of analysis while considering different air quality standards for ozone.[22] In such a procedure, the several steps from release and exposure to ultimate health effects are carefully described. A panel of experts is convened to evaluate the parameters for each step. The resulting range of opinion can be used both as a measure of the central tendency of expert opinion and as an index of the dispersion of uncertainty inherent in that body of opinion.

When scientific data is better, a number of other approaches may be used. Where data permit it, multiple regression analysis can be used to assess the possible long-range human health effects from exposure to a suspect substance, expressing possible adverse health effects as the dependent variable and exposures to suspect substances as the independent variables.[23] In such an assessment, it is critical to control for other variables that may also affect health--such as income, occupation, age and smoking, eating and drinking habits of the population. Most criticisms of the epidemiological approach, especially from the scientific community, center around the inadequacy of these control variables and the failure to specify the models according to well formulated scientific hypotheses. These criticisms can be overcome in long-term case control studies, but doses of harmful substances ordinarily are limited to normal or near normal background levels. Reliable results can be obtained only if large populations are given varying exposures to the harmful substance. A rare example of such an experiment is the long-term study of Japanese A-bomb survivors discussed in Appendix A, the section on radiation regulation. While definite limitations exist for epidemiological studies, these approaches can provide useful information on the linkages between past exposures and current health effects.

A related approach, termed an episodic study, can be used to measure short-run health impacts from current exposures to a substance. In episodic studies multiple regression analysis may again be used to explain hospital admissions, for example, with data on current or recent population exposures to various air pollutants. Such approaches reveal little or nothing about long-run impacts, but they do reveal a wealth of information on short-run morbidity impacts. These latter impacts may be just as interesting to the regulatory agencies as are chronic morbidity and mortality.

Another possible means of expressing environmental risks is used in decision analyses and is termed the fault tree.[24] This approach has been widely used to assess the probability of catastrophic events involving safety--for example, the safety of nuclear reactors.[25] In a fault tree assessment, all known pathways to an ultimate catastrophy are delineated and probabilities are attached to each separate division in the path. The probability of adverse outcomes is obtained by summing the probabilities of successfully following any of the separate paths to disaster. The main criticism of this approach is not so much that the probability of the events described is inaccurate, but that unknown pathways often exist for relatively untried technologies.

Although not stressed as often, technological uncertainty of the type mentioned above also plagues the calculation of benefits. Insenstive or inaccurate hazard monitoring and testing devices or untried testing control technologies, for example, can lead to benefit estimation that can only be established as a range of possible effects.[26] For example, OSHA health standards often rely on "technology forcing" as a means of achieving a desired emission level. That is, the use of technologies "looming on the horizon" can be required as part of the standard. To the extent that these technologies are not effective in achieving the desired goal, benefit assessments based on their use will be uncertain and, in this situation, overestimated.

Just as significant uncertainty may be associated with benefit estimates, the costs associated with a particular regulatory program may also be difficult to quantify accurately. Several groups provided cost estimates for the OSHA coke oven emission standards. The wide range of these estimates reflect the variation in the assumptions made concerning: a) how the regulations are to be interpreted; b) the length of time before 100% compliance is achieved; and (c) the cost elements that should be included in the analysis. Perhaps more important is the difficulty of predicting the actual costs that will be incurred by an industry resulting from shifts in the utilization of resources and technologies within a firm that occur after the regulation is in place. For example, during the course of the rulemaking process on OSHA's vinyl chloride standard, industry spokesmen claimed that the regulation would impose huge costs on the industry. In fact, however, actual costs have been significantly lower due to production and technology shifts in the industry.

Cost measurement difficulties are compounded by the expense of acquiring information on firms in the industry. For all but the smallest industries, it is not possible to estimate costs for each firm. Rather, agencies must rely on model plant data that is extrapolated to the industry as a whole. If the model plant is descriptive of much of the industry, such analysis may provide a realistic picture of the costs imposed by a regulation; however, if the industry is particularly heterogeneous, this approach may reveal little about such problems as actual plant closings and unemployment. Furthermore, in estimating these costs agencies must rely primarily on data provided by industry. If an industry feels that the regulation will cause significant financial harm, it may have an incentive to increase its cost estimates to the agency.

Finally, it is noteworthy that the usual engineering cost estimates generated during the course of a rulemaking process are not, in the form normally reported, appropriate for use in cost/benefit analysis. In an economic sense, the costs of a regulatory program are measured by the change to consumer and producer surplus that results from price changes. Calculation of surplus losses or gains requires a knowledge of the market demand and supply conditions for the affected commodity and the long-run shifts in the supply of the commodity due to increased regulatory costs. Innovation and technological change in response to the regulatory stimulus is particularly difficult to predict. But when careful ex post facto analyses are conducted, the social or welfare cost of a regulation is often considerably lower than the simple capital, operating and maintenance costs estimated. Accurate social cost estimates would require knowledge of demand and supply shifts due to incresed regulatory costs. Rarely are the parameters developed that are needed to estimate these shifts.

This point is illustrated by the cost estimates provided by FDA during promulgation of the proposed saccharin ban. These costs were estimated to range from $715-$2079.6 million and included lost sales to diet food and beverage industries, lost sales to the sole domestic producer of saccharin and the costs of reformulating products with alternative sweeteners. (These estimates do not include the costs of banning the use of saccharin in drug products. These were treated separately by the FDA.) These costs are misleading in two respects.

First, the value of lost sales is not a long-run cost since resources previously used in the production of products containing saccharin are transferred to other productive services which generate other sales. However, there is a short-run cost involved in the loss of the production capacity. If the value of lost sales is subtracted from the cost estimates, the potential cost of the regulation in terms of increased production costs may be in the range of $107.8-$110.3 million. (See Regulatory Case Studies, Saccharin, Appendix A.)

Second, if these costs were passed on to consumers through price increases and then translated into consumer surplus losses they would most probably be significantly less. This is due to the fact that the proposed ban does not restrict all uses for saccharin and the demand for saccharin products may be quite elastic, considering the number of alternatives to presweetened saccharin-containing products. The Council on Wage and Price Stability estimated the lost consumer surplus at $144-$182 million, but only by assuming an inelastic demand and a total ban on saccharin consumption.

Though useful techniques have been identified to help analysts and decisionmakers treat uncertainty within program evaluation, these methods have certain drawbacks. For example, if the probability distribution of costs and benefits is roughly known, the expected value of the benefits and costs can be computed by isolating the benefits and costs associated with alternative outcomes and aggregating these values using the probability of each outcome as weights. Although this approach would identify the most likely combination of costs and benefits, it might also lead to decisions, particularly in the case of catastrophic or irreversible events, that are inconsistent with the risk preference structure of society. If society can be characterized as risk adverse, they might be willing to expend greater resources to protect against the small probability of a disastrous event than would be suggested by a cost/benefit analysis using expected value. On the other hand, as has already been mentioned, such "worst case" decision-making could entail larger expenditures to control environmental, health, and safety risks than society is willing to allocate.

Equity and Ethics

The costs of regulatory programs directed at environmental, health and safety risks are rarely imposed on the beneficiaries of the program. Benefits and costs often accrue across different regions, income groups, and different generations. The balancing of those who should pay and those who should gain is essentially a political/legal decision defined in terms of society's underlying ethical code. With respect to such distributional considerations, economics has little normative advice to offer. Economists generally treat such concerns by assuming that income transfers can always be arranged to compensate for adverse distributional impacts. Even when intergenerational equity is at issue, as it is in the case of radioactive waste management, it may be possible for the beneficiaries in one generation to set aside a portion of the benefits to serve as compensation to the victims in some future generation. Such reasoning falls apart, though, when the potential adverse future outcomes are large, as may be case with ozone depletion by chlorofluorocarbons. In these situations it may be impossible for current beneficiaries to invest the benefits so as to compensate future losers even if institutional and political barriers to establishing compensation funds could be overcome.

Recently, economists have become more aware of the distributional consequences of their analyses, and have tried to go beyond a simple accounting statement of who wins and who loses. A study by economists at Resources for the Future and the Universities of Wyoming and New Mexico represents one of the first careful attempts by economists to determine the intergenerational distribution consequences of cost/benefit analyses.[27] Their study addresses the effect of alternative ethical assumptions on the solutions obtained through a balancing of costs and benefits. Treatment of inter- and intra-generational issues is dependent on the implied valuation of the ethical precepts. An in-depth description of the study's assumptions and results is not warranted here; it is sufficient to note that cost/benefit techniques are not value free and that ethical considerations do play a dominant role in decisions that involve future costs and effects or that have impact on the distribution of wealth and income.

Value of Life

An increasingly controversial issue in cost/benefit analysis is the value that should be assigned to human lives saved. Though this thorny issue is skirted in cost/effectiveness and risk/benefit analysis, cost/benefit analysis must directly confront the problem of valuing morbidity and mortality effects in dollar terms (or some other metric). Information on these values can be obtained through a variety of avenues, such as the present value of future earnings, the wage premiums earned in risky occupations, or expenditures on life and medical insurance. Martin Bailey in Reducing Risks to Life describes these and other approaches in considerable detail and concludes that willingness to pay to avoid risk is partly measured by wage premiums for risky occupations, but that other adjustments must be made for social insurance and other social benefits of reducing risks. He recommends that a range of about $250,000 to $450,000 be used as the value of a life for purposes of program evaluation. This valuation is independent of other factors that one may want to consider--such as the average age and health of the population at risk--and consequently is not the final word.

Others are not convinced that such techniques are appropriately applied to human lives and would rather leave the valuations as implicit in legislative or policy decisions. An attempt to resolve this controversy will not be made here. It is noteworthy, however, that although many regulatory decisions imply certain values to the reduction in risk to human life, explicit determination is the final step in a process fraught with inadequate data and uncertainties. As a practical matter, these uncertainties will limit the usefulness of cost/benefit analysis before human life valuations will.

Legislative Constraints

One of the most significant factors affecting the applicability of cost/benefit analyses (and for the large differences in cost per life saved in Table 1) is not a function of the techniques themselves. Rather, OSHA and other regulatory agencies typically have been given strict legislative mandates that limit their flexibility for more effective agency decision-making and their consideration of cost/benefit tradeoffs. For example, promulgation of the coke oven emission standard was directed by Section 655(b)(5) of the Occupational, Safety and Health Act (OSH Act) which states:

> The Secretary . . . shall set the standard which most adequately assures, to the extent feasible, on the basis of the best available evidence, that no employee will suffer material impairment of health or functional capacity even if such employee has regular exposure to the hazard dealt with by such standard for the period of his working life. . . . In addition to the attainment of the highest degree of health and safety protection for the employee, other considerations shall be the latest available scientific data in the field (and) the feasibility of the standards. . . .[28]

It is clear that the Agency is to give greater emphasis to reducing health effects than it is to related costs. Although feasibility is required, the term has been loosely defined by the courts to include technological feasibility (currently in use or "looming on the horizon") and economic costs (allowing some firms to go out of business but not to force "massive dislocation"). While there is a legal question as to whether OSHA must explicitly weigh costs and benefits, current Agency interpretation dismisses this requirement. Under the OSH Act OSHA is left little leeway if a substance is thought to increase a health risk, it must regulate up to the point of economic and technological feasibility, regardless of the relationship between costs and benefits.

A similar but distinct example involves FDA's handling of saccharin and aflatoxins under the Food, Drug and Cosmetics Act (FDCA). Both substances are known to be potential carcinogens in humans, saccharin very weak and aflatoxins relatively strong. Because the FDCA places a much greater emphasis on food additives such as saccharin than on naturally occurring substances such as aflatoxin, FDA is forced to regulate saccharin closely while limited action is taken against aflatoxin.

While legislative mandates affect the extent to which and the manner in which regulatory resources can be allocated, cost/benefit considerations are almost always a part of a regulatory program. Variances, relaxed enforcement, and delayed compliance schedules permit the agency some degree of flexibility in trading off costs and benefits. A recent example is OSHA's decision not to enforce portions of its cotton dust standard for certain segments of the cotton industry where exposures are relatively low. Although such decisions are rarely accompanied by a formal cost/benefit analysis they represent an implicit judgment by the decisionmakers that the benefits of forced compliance may not, in some cases, justify the costs.

IMPLICATIONS FOR HAZARDOUS WASTE MANAGEMENT

The preceding discussion has attempted to provide an accurate overview of cost/benefit techniques and their ability to guide the development of environmental, health and safety rules. This final section offers some general observations on the incorporation of cost/benefit concepts in hazardous waste management. The remaining sections of this report provide the necessary detail. Before beginning, two general conclusions that bear directly on the regulatory problems posed by hazardous wastes should be highlighted. First, though data limitations and uncertainties will almost always preclude the formal application of cost/benefit approaches, the economic spirit of these techniques provides indispensible information to decisionmakers. Specifically, the emphasis on identifying and quantifying, to the extent possible, all positive and negative consequences of an action forces decisionmakers to look at the full range of alternatives in regulating EHS risks and minimizes the chance that important effects are overlooked. This observation is hardly new; many people have stated that cost/benefit consideration is a useful way of organizing and arranging information. Second, the use of cost/benefit techniques cannot be viewed separately from other allocative forces such as equity concern and legislative/legal constraints. These decision criteria are crucial guideposts within which regulatory consequences must be considered.

All of the factors limiting the application of cost/benefit technique to EHS risk management apply to hazardous waste management policy. The most severe barrier is the paucity of information concerning the nature of the hazards, which is particularly acute in regard to the management of inactive or abandoned sites. Although there have been recent attempts to identify the location of disposal sites, many more are still undiscovered.[29] The cost to the government of locating abandoned hazardous waste disposal sites is huge, and the entire process will become progressively more difficult as the easily identifiable areas are found. Even if all the sites can be identified, the wastes contained in the sites (their chemical composition, etc.) and the health risks posed are largely unknown. Extensive testing of the site must be undertaken to determine what hazards are posed by the wastes. Furthermore, safe inactive sites have to be distinguished from those sites that have the potential to become health hazards.

The current regulatory approach to the problems briefly discussed above requires that the federal and state governments take the lead in locating, identifying and characterizing waste disposal sites. Cleanup costs and penalties are being sought from the current owners and past users in civil proceedings. Unfortunately in this process, there exist incentives for the disposing party to conceal valuable information from the government and perhaps to contribute to further social harm. The total cost of acquiring the necessary information could be lessened if the entities that can generate the information most cheaply, private firms for example, had incentives to volunteer whatever site and waste characteristics they have.

Private firms, when deciding whether or not to reveal past dumping activities that may represent a health or environmental hazard, weigh the expected private consequences from providing the information. In the face of potential civil or criminal proceedings if they are found culpable, it may be in their best interest to reveal as little as possible. In structuring a cost/effective regulatory policy the government must take these private calculations into account. For example, the government may want to consider exempting firms from legal proceedings if the firms make their knowledge on the existence and characteristics of disposal sites available. Coupling such a policy with harsh sanctions against recalcitrant firms could provide an effective mechanism for obtaining necessary information.

Serious distributional questions arise when considering any options for cleaning up hazardous waste disposal sites. One of the most important questions is concerned with who should pay the cleanup costs. Generally accepted notions of equity would suggest that those who benefited from the disposal operations (i.e., the firm that experienced lower disposal costs and therefore the consumers of the output produced by the firm or in the case of a municipal site, local taxpayers) should pay the costs associated with the activity. Unfortunately, implementing this concept is complicated by the long periods between disposal and the date of regulatory action; these time lags make it difficult to identify the actual beneficiaries of the waste-generating activity. In addition, even if the responsible firm or disposal entity can be identified, it may be out of business or unable to meet the cleanup costs. If the firm is able to pay the cleanup costs and transfer these costs to consumers in the form of higher prices, the ultimate incidence of the costs will likely bear little relation to the earlier distribution of benefits from improper disposal. In situations such as these where it is impractical or impossible to identify the beneficiaries of the unsafe disposal practices or where the responsible parties are not able to pay the bill, the regulating agency must decide how the cleanup efforts will be financed.

Most of the current proposals that address the problem of financing cleanup efforts make no attempt to cope with the distributional questions raised here. Litigation efforts directed at demonstrating liability are only focused on current owners of land if a site is found. As is sometimes the case, the present owner may have purchased the land with no knowledge of the disposal site's existence. Although the current owner may be able to institute similar litigation against the individual from whom he purchased the property, it must be demonstrated that the seller misrepresented the property to the buyer. This may be difficult to prove unless the issue of the disposal site was made explicit at the time of sale.

The recently enacted superfund represents an attempt to deal with cleanup costs for hazardous wastes and to compensate victims of spills for their economic losses. In general, initial funding of the superfund would be achieved by taxing current production of materials that produce hazardous wastes as residues, with the federal government supplementing the fund with other tax revenues. Generally, the superfund would supply funds immediately for cleanup and compensation; later, the spiller would be sued in order to replenish the fund.

The concepts behind superfund raise the previously noted equity issues of whether current consumers should pay for past mistakes from which they may not have benefited and whether firms that are now safely disposing their wastes should have to subsidize, in effect, less clean or environmentally sound firms.

Thus far this discussion has focused on the proper management of abandoned disposal sites. Regulations now being developed under the Resource Conservation and Recovery Act address management practices for active disposal sites. These regulations are structured largely to prevent contamination of underground aquifiers. Cost/benefit analysis can contribute to the regulatory decisions; the maximum amount that should be spent to protect ground water is given by the minimum cost associated with the alternative options of (1) doing nothing and suffering the adverse effects on health and the environment, (2) treating the contaminated water before consuming it, and (3) obtaining alternative supplies from uncontaminated areas.

A broader perspective of hazardous waste management practices would also include actions that could be taken to reduce the flow of hazardous wastes. In fact, current regulatory efforts may work against this scale. By raising the costs of transportation and disposal of wastes, the regulations do provide an incentive to reduce the quantity of waste which requires handling; however they may also provide an incentive to bypass the legal treatment system and dispose of more wastes improperly. Cost/benefit consideration would suggest a greater emphasis on regulatory programs with direct economic incentives that may be more cost-effective in a long-run. For example, coupling a product charge on hazardous waste generating activities with subsidized disposal centers, marketable disposal permits, tax credits for recycling hazardous wastes, and variable fine structures should be considered and evaluated as possible control mechanisms.

In addition, the current regulations assume implicitly that the supply of safe hazardous waste disposal facilities will keep pace with the expanding volume and number of wastes requiring treatment. Public opposition, though, to the siting of disposal plants may severely limit the number of available sites for such facilities. In an economic sense, this opposition is a rational response if communities feel that a hazardous waste disposal plant would impose external costs (i.e., increased risk of adverse health effects) without providing corresponding benefits. This skewness of costs and benefits (where the benefits accrue to a larger regional area) might result in a scarcity of sites and/or in sites that are located too far from generating activities. As public concern and

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awareness of the potential risks posed by hazardous waste disposal facilities increases, it is likely that federal or state policy initiatives will have to be developed that provide for an adequate number of waste treatment centers.

Finally, it is useful to discuss briefly the importance of distinguishing between different levels of hazardous waste health risks in setting regulatory policy. The previous discussion on cost/benefit analysis suggests that more stringent (and therefore more costly) standards should be set for the more hazardous wastes and less stringent standards for those wastes that pose smaller health risks. If this flexibility is not present, a serious misallocation of resources will result with some risks being overregulated, in the sense that dollars spent elsewhere would provide greater reduction in health risks, and some risks not being regulated strictly enough.

The regulations under Subtitle C of RCRA only allow for a minimal amount of such ranking of hazardous waste health risks or of alternative regulatory strategies by health risk class. Though the required scientific and medical information for establishing such classes may not yet be available, research efforts directed toward the goal of generating that information would be valuable.

SUMMARY AND CONCLUSIONS

The important characteristics of cost/benefit analysis and its principal variants, risk/benefit and cost/effectiveness analyses, have been outlined and described. While these techniques have been applied recently to the issues of health, safety and environmental risk, some difficulties are encountered. Uncertainty over health effects, environmental effects, and economic costs is a characteristic common to most of these risks. In addition, many of the risks involve significant redistributions of wealth and income among those of us alive today or between present and future generations. These issues have been illustrated with examples from case studies of four federal regulations.

The remainder of this section turned to special issues in hazardous wastes management. While the scientific uncertainties and distributional questions effectively constrain the formal application of cost/benefit techniques, the general concerns or "spirit" of cost/benefit analysis can provide invaluable insights to the development of sound regulatory policy. Regulation of hazardous waste should utilize cost/benefit concepts because they provide a fuller analysis of all the regulatory alternatives and an examination of their positive and negative consequences.

The final two sections of this report demonstrate in more detail how the concepts of cost/benefit analysis can be applied to two specific regulatory problems posed by hazardous waste generation and disposal. First, an existing but new program, superfund, affecting past, present and future disposal practices is evaluated. Superfund was selected for this investigation because it incorporates some of the transaction cost reduction alternatives suggested in Section 2; and because it directly and indirectly affects all aspects of hazardous waste management. The focus of the analysis will be to identify some of its more important costs and benefits, both of which are often hidden, and to use this information to make qualitative statements of its relative effectiveness.

The second problem analysis involved a hazardous waste management concern that has yet to be directly addressed at a federal level, but where suggestions of a potential government role have been made: siting of hazardous waste disposal facilities. A careful economic review of the underlying causes of the siting problem and the costs and benefits of federal action can help determine the level of government that is required and the form of that action, if any.

The two studies suggest a thought process that can be applied usefully to regulatory analyses. The discussion is qualitative and is intended to provide a general model in which more rigorous analyses can be conducted. The economic focus of the studies serves to organize the available information on the issue, identify its strengths and weaknesses, and identify some likely regulatory alternatives.

SECTION V

SUPERFUND: COPING WITH ORPHANED HAZARDOUS WASTE SITES AND SPILLS

Of the range of problems presented by hazardous wastes, perhaps none are more difficult to cope with than those associated with past dumping practices and accidental spills or discharges. More than 30,000 chemical waste dumpsites may currently exist, and as many as 2,000 of those may pose a significant risk to businesses, residents and wildlife located near the site.[30] Although responsible parties have often made efforts to locate and clean-up such sites, at least two factors limit the number of sites to which this applies. First, waste sites are often "orphaned" to the extent that the original responsible party is no longer known or that the current or past owner is not able financially to cover the clean-up costs and potential compensation damages. Second, a strong incentive exists for responsible firms or individuals to withhold information on a particular site; if they withhold the data and are not caught, they are far better off.

In addition, if toxic wastes were accidently spilled or discharged, few avenues, until recently, were available for individuals or the government to mitigate potential environmental and health risks. The heavy information requirements to bring common law actions have already been noted. Though several federal statutes provided some basis for action, they are limited in their scope. Finally, given the potentially high costs of volunteering information on a spill or discharge versus the low probability of being caught and held liable if a party withholds relevant data, there was little incentive to come forward and take responsibility for an accident.

In direct response to these, and other problems, Congress enacted the Comprehensive Environmental Response, Compensation and Liability Act in the fall of 1980 (hereafter referred to as Superfund). In essence, the bill provided broad federal government emergency response authority for hazardous waste spills and provided tools for coping with orphaned sites. This section will describe the statutory shortcomings that led to the enactment of Superfund and will then review the Act in light of those limitations. After establishing the statutory background the analysis will then attempt to cast Superfund in a qualitative cost/benefit framework. This will demonstrate the usefulness of such an approach for identifying the critical policy questions to be considered before promulgating Superfund regulations.

BACKGROUND

The law existing before Superfund was inadequate for cleaning up abandoned hazardous waste sites. Although at least 21 federal statutes provided some authority for controlling hazardous waste sites,[31] with the major provisions being in the Clean Water Act (CWA)[32] and the Resource Conservation and Recovery Act (RCRA),[33] the federal government was limited in its ability to respond to dangerous hazardous waste disposal sites or to require the responsible parties to take clean-up actions. Recovering the government's costs associated with cleaning up a dangerous site was in most circumstances nearly impossible. In addition, the government could not compel companies and individuals to disclose the history of their waste dumping practices and the location of their dumpsites, further restricting its ability to identify the sites in need of remedial action and as well as to build cases against the responsible parties. These points are discussed in more detail below.

Response Authority

Before the passage of Superfund, three sections of statutory law provided some limited response authority. Section 311 of the Clean Water Act allows the government to take remedial action, or require the responsible parties to do so, for spills of oil or approximately 300 designated hazardous chemicals in navigable waters. This response authority is characterized by several notable deficiencies. First, it applies to only a small portion of the actually hazardous chemicals; some observers claim that several thousand chemicals should be considered sufficiently dangerous to be included among those chemicals for which the government has response authority.[34] Second, spills into navigable waters constitute only a small portion of the hazardous releases into the environment; spills often contaminate groundwater, soil, or air without affecting navigable waters and cannot be addressed under this section of the Clean Water Act. Finally, as of May, 1980, the fund used to finance the government's initial clean-up operations under Section 311 was virtually depleted.[35]

Section 504 of the Clean Water Act[36] (CWA) also provides broad authority for response, enabling the government to provide assistance in any pollution emergency. However, the $10 million designated to be placed in a fund for providing such assistance was never appropriated; in any case this amount would have been too small to cope with the hundreds of abandoned hazardous waste sites.

Section 7003 of RCRA permits the government to bring an enforcement action against any person contributing to the release of hazardous waste which presents an imminent and substantial endangerment to public health and the environment. Although intended to address directly the problem of spills and orphaned sites, the judicial proceedings under this provision are cumbersome, slow, and expensive. Further, it requires that the government identify the responsible parties before bringing suit and that such parties have the resources necessary for cleaning a site up before any remedial action could be taken. Under this process remedial action could have taken several years.

Cost Recovery

Before Superfund the government could not recover emergency response costs of all hazardous waste contamination incidents. Sections 311 and 504 of the Clean Water Act (CWA) empowered the government to recover only those costs associated with cleaning up spills in navigable waters of oil or the designated hazardous substances; recovery was obtained through civil actions. Because of the dependence on the judicial system, years could pass before the government would be reimbursed for the expenditures made to clean up a spill. Thus, the government's ability to recover costs was limited to a relatively narrow subset of potentially dangerous spills, and was subject to the normal delays found in judicial proceedings.

Reporting and Notification

Although requirements for reporting spills and notifying authorities about hazardous waste contamination of the environment existed before the passage of Superfund, they were not broad enough to cover all hazardous wastes. The only spills that responsible parties were required to report were those where oil and designated chemical substances were spilled in navigable waters.

Summary

In summary, statutory law existing before the passage of Superfund left serious institutional and legal gaps. More than 21 federal statutes pertained to hazardous waste management, but the only spills that were required to be reported to government officials were those of oil or a limited number of hazardous chemicals which contaminated navigable waters. Many other spills, either those of different substances or those not contaminating navigable waters, were never disclosed so that authorities and pollution victims were unable to take action to force clean-up and compensation payments. Similarly, the government had authority for cleaning up and recovering costs only for those spills covered under Section 311 of the CWA, which left out a large number of sites. Even for spills covered under Section 311, EPA was given inadequate resources to finance clean-up operations. Judicial proceedings to force clean-up of spills often took years to resolve. Superfund and the many versions which preceded it sought to address these issues. The approach taken in Superfund to resolve each of these problems is described below.

PROVISIONS OF SUPERFUND

Superfund expands the scope of government response authority to cover more substances--not only those under CWA, but also substances listed under specific sections of RCRA, the Clean Air Act, and the Toxic Substances Control Act. In addition, the government can designate additional hazardous substances if needed. In general, response authority is provided for "any pollutant or contaminant which may present an imminent and substantial danger to the public health or welfare."[37] With the exception of certain statutorily excluded substances, such as most petroleum fractions and various forms of natural gas, response authority under Superfund appears to include a broad class of substances.

Response Authority

Superfund authorizes the federal and state governments to undertake removal and remedial actions necessary to protect public health and welfare or the environment.[38] The government is to broaden the scope of the National Contingency Plan developed under the Clean Water Act to respond to releases or to substantial threats of releases of hazardous substances. The sole exception is if the President determines that the party responsible for the release will conduct the removal or remedial actions properly. The responses include, but are not limited to, containing or treating the wastes at the site and providing alternative water supplies and monitoring.

Funding of governmental response efforts comes from the Hazardous Substance Response Trust Fund. This fund will contain 1.6 billion dollars over a 5-year period, of which 12.5% will come from government general revenues and 87.5% from taxes on industry. The taxes are to be levied on feedstocks, inorganic chemicals, and oil.[39]

Cost Recovery: The Liability Provisions

Considerable controversy surrounded the development of the liability provisions of Superfund. The original Senate version would have authorized the recovery of removal costs incurred by the government or any person by mandating strict, joint and several liability against parties involved in the generation, transport, or disposal of hazardous wastes.[40] The responsible parties would also have been liable for certain other damages, such as resource restoration and replacement. The final bill makes no mention of strict, joint and several liability and does not provide victims with direct access to federal courts. On further examination, however, the liability provisions may be, due to precedents in interpreting similar wording in other statutes, very close to strict, joint and several liability.

Strict liability is the holding of parties involved in a disposal process liable regardless of any negligence. The standard of liability in the new law is intended to be the same as that imposed in Section 311 of the Clean Water Act, which has been interpreted to be strict liability.[41] Certain specifically enumerated defenses are available, namely showing that the release was caused by (1) an act of God, (2) an act of war, or (3) an act or omission of an independent third party; however, the third party defense is narrowly defined to exclude the actions of employees, agents or contractors.[42] This would make a generator liable for the actions of its transporters and disposers. The weight of this evidence, particularly the precedent of the interpretation of similar language in Section 311 of CWA, suggests that Superfund applies strict liability to parties involved in hazardous waste management.

Whether the parties involved in hazardous waste disposal will be held jointly and severally liable is a more difficult question. Joint and several liability could make any participant liable in an action, regardless of the extent of participation. For example, under these liability rules a single generator could be held liable for all costs and damages caused by the combined wastes disposed at one site by several generators. Costs could be recovered from one generator while distribution of the costs and damages among the other contributing parties is left to future law suits. Support for assuming that parties involved in hazardous waste management are jointly and severally liable under Superfund is found in the language of the Act which states "nothing in (it) shall affect or modify in any way the obligations or liabilities under other Federal or State law, including common law, with respect to releases in hazardous substances."[43] According to the Department of Justice, common law provides for joint and several liability where the act or omission of the responsible parties results in an indivisible injury.[44] Further support for holding the parties jointly and severally liable is found in several pending suits in which the Department of Justice interprets Section 311 of the Clean Water Act as applying joint and several liability.[45] The issue of whether joint and several liability will be imposed on parties contributing to a hazardous waste site will be developed and clarified through case law.

Reporting and Notification

Superfund establishes requirements for reporting and notifying authorities about unpermitted hazardous waste facilities and hazardous substance spills (Section 102). It requires any person in charge of a vessel or facility that is releasing hazardous substances that are equal to, or greater than, a given quantity to report immediately the release to the National Response Center. Failure to do so exposes the person to the threat of up to 10,000 dollars in fines or up to one year imprisonment, or both (Section 103).

Under Superfund, the existence of unpermitted facilities must be reported to EPA within 180 days of the law's enactment. Failure to report these facilities may result in up to 10,000 dollars in fines, or one year imprisonment, or both, for any person involved in putting hazardous wastes at the site. In addition, Superfund prohibits any person from knowingly destroying records that specify, in accordance with EPA regulations, the location of and hazardous constitutents present in a facility. This prohibition applies for 50 years after the enactment of the Act, or 50 years after establishment of a record, whichever is later. Any person who violates this requirement may be fined up to 20,000 dollars, or imprisoned for up to 1 year, or both.[46]

COST/BENEFIT ANALYSIS

The problem of coping with past disposal practices is a classic case of an externality. Before RCRA and Superfund, few incentives existed for generators, transporters, and diposers of hazardous wastes to take precautions against adverse health and environmental effects. The underlying reasons for the lack of incentives were given in Section III. High transaction costs in terms of informational uncertainty and identification of responsible parties led to fewer negotiations between affected parties before an activity commenced and fewer tort actions after the fact. Therefore, costs imposed by hazardous waste activities were not internalized by the responsible party, and the level of safety reached in dealing with hazardous wastes did not fully reflect society's risk preferences. These transaction costs were exacerbated by problem sites where a financially viable owner no longer existed.

In many respects Superfund directly addresses the root causes of the externalities associated with hazardous wastes. It implicitly recognizes the role played by transaction costs in inhibiting economic/legal transactions that would internalize the social costs of unsafely disposed and treated wastes. High costs resulting from informational uncertainties (i.e., the location of past dump sites, current spills, and composition of the wastes) are intended to be lessened through the notification requirements. This intention corresponds to a theoretical argument that in the case of uncertainty over the least cost avoidance of an externality, responsibility for avoidance should be placed with the party who can estimate these costs most cheaply, in this case, generators, transporters, and disposers of wastes.[47] The liability provisions, to the extent that they are interpreted as meaning strict, joint and several liability, also shift the burden of transaction costs to the private sector. The effects of uncertainty concerning exact causal relationships is somewhat mitigated in favor of the damaged party and the use of the fund does not require the identification of all of the responsible parties.

Reviewing Superfund within a cost/benefit framework can be done at two different levels. First, one could evaluate the relative value of the Act itself. That is, the marginal costs and benefits of Superfund could be compared to other options available to Congress to determine if the chosen route maximizes net benefits. Alternatively, one could take Superfund as a given and assess alternative agency actions within the Act to assure that costs and benefits are equated at the margin for each selected action. The latter approach is clearly more relevant for the EPA in the sense that it must choose among alternatives that fit within the legislative mandate; the more detailed and restrictive the Act is, the less flexibility EPA has in determining efficient regulatory and implementation policies. This section offers a general analysis that applies at both levels mentioned above. By identifying the major cost and benefit elements of the Act, some specific concerns in revising Superfund and in implementing its requirements can be isolated. For example, cost/benefit concepts can be used to organize regulatory program information in order to determine its effectiveness in addressing problems such as data requirements and uncertainties and gaps or overlaps with existing legislative or market mechanisms.

Benefits

The general class of benefits from Superfund is the value of damages avoided from improperly disposed wastes. These benefits are generated through several avenues. Shortened clean-up response time to dangerous sites or spills is expected to lessen potential damages. For example, the benefit of controlling a site that has been leaking a particular substance that harms surrounding plant life is defined by the value of the difference in plant damages averted as the result of acting promptly. The liability provisions create an additional incentive for the firms handling hazardous wastes to be more cautious. Benefits therefore result in the present and future as firms re-design or close existing sites and as they incorporate better control technologies to reduce their potential liability. Again, the benefits are defined in terms of the value of damages avoided as a result of these actions.

The earlier discussion isolates two specific classes of damages from hazardous wastes: health (chronic and acute) and natural resource (including wildlife). Because Superfund permits the government to seek compensation for natural resource damage as well as clean-up costs, reduced natural resource damage as well as reduced clean-up costs is a direct benefit from the program. Even though Superfund does not explicitly address personal injury damages, there will be health benefits from the Act. To the extent that the internalization of other social cost elements acts to induce safer behavior on the part of firms, health damages will also be averted.

Benefits from the fund mechanism and tax scheme are more difficult to generalize. On one hand, that part of the act represents solely an income transfer mechanism and the only benefits that accrue are those that result from the emergency response authortiy and increased compensation payments to injured parties. Where the money comes from is of little interest from an efficiency standpoint. On the other hand, the tax does act as a partial incentive to control hazardous waste streams. It states, in essence, that a firm must buy the right to generate wastes. Ideally, some firms, depending on their cost structures, would pay the tax, and others would opt for changing production processes and not generating wastes. The limitations of this incentive from the Superfund scheme will be discussed later. At this point it is sufficient to note the possibility of some benefits resulting directly from the taxing authority of the act.

Actual estimation of the benefits from Superfund involves a process similar to the estimation of benefits from any other regulatory program. Estimates must be made of:

1) the change in ambient environmental concentrations--for Superfund this means the difference in the number of uncontrolled or cleaned up sites now and in the future;

2) the change in the number of exposed individuals, natural resources (acres of land, or numbers of animals) resulting from Superfund;

3) the change in the level and type of exposure experienced by the population (for example, ten fewer people will be exposed to contaminated groundwater);

4) the relationship between the level of exposure and resulting health or damage effects--for health effects, exposure will be defined in terms of dosage--for resource damages, the relationship will be defined as level and duration of exposure to toxic chemical;

5) the change in number of adverse health or natural resources damages--for example, as a result of Superfund there will be 5 fewer mortal cancers each year for the 30 years and 2000 fewer destroyed wetland breeding habitats; and

6) the economic value of the change in health and natural resource damages.

Obtaining numerical estimates for each stage of the computational procedure is thwarted by data, methodology and technology uncertainties that are common to any benefit assessment. In addition, there are several problems with obtaining accurate estimates that are somewhat, but not entirely, unique to hazardous wastes. These will be briefly discussed in turn.

Conducting a prospective rather than retrospective analysis is always complicated by having to superimpose a regulatory program, in this case a legal/economic/regulatory scheme, on existing patterns of behavior at the individual and market level. Where the regulation specifies a particular target level, predicting the number of sites that each year will be brought under control by the government can be approximated by the amount of funds available for clean-up actions and the average clean-up cost per site. The number of future sites or spills, the clean-up of which will be avoided because of more cautious industry behavior, requires a number of assumptions. These would include, for example, the ultimate effect of the tax on producer behavior, the degree of change in the level of uncertainty and therefore transaction

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costs associated with bringing personal injury actions, and the extent to which the costs internalized through recovery of clean-up and natural resource damage costs accurately reflect true social costs.

Computation of economic values is made difficult by the wide variety of potential damages within the two general classes of benefits. Some of these benefits may be reflected in property value changes for land located near or next to a site.[48] Estimates of property value changes that have occurred at a few known sites could be used to value expected benefits if the degree of change could be characterized by size of site, type of chemicals, location, geo-physical variables, etc. The value of expected health benefits, assuming health effects can be quantified, could be estimated by one of the techniques discussed in Section IV. Of course, the relevant uncertainties still hold. The problems of placing values on benefits to future generations of clean-up activities resulting from Superfund have already been mentioned and are complicated by the selection of an appropriate discount rate.

Short of computing dollar values for the positive effects of Superfund, a less demanding measure of effectiveness could be designed that would provide useful information to the policymaker. For example, it may be possible to define a series of categories for orphaned hazardous waste sites that reflect varying degrees of health or environmental risks. For example, sites that pose a large risk of causing human health effects would be placed in a higher class than sites which have a risk of destroying the productive capacity of surrounding land, but not of damaging health. The effectiveness of Superfund, or alternative implementation strategies, could then be measured in terms of the number of sites or spills in each class that were controlled or averted. As will be discussed later, this type of approach might be useful in a cost/effectiveness analysis.

Costs

In general terms, the costs of Superfund are: the change in clean-up and restoration costs; direct costs to firms of reporting and notifying EPA of spills; increased compensation costs to firms resulting from common actions involving personal damages; and the fund tax. Ideally, estimates of private costs accruing to the firms should be translated into social costs, i.e., estimates of consumer and producer surplus losses. The most important steps are summarized generally below.

1) Estimate the number of sites or spills that will require clean-up action at each point in time.

2) Estimate the costs associated with those operations including restoration costs and natural resource damage costs, compensation for which can be obtained through the fund and, later, responsible parties. Most likely these cost estimates would only be approximated by the average cost of clean-up per site. A further refinement would allow estimates based on certain site characteristics such as size or type of wastes.

3) Estimate the total costs of the clean-up operation (1 x 2).

4) Estimate the shift in the cost or production functions of affected firms.

5) Estimate the resulting shifts in the supply and demand of the goods, the production of which generate hazardous wastes.

If each step is carried out properly, it is possible to determine how much of the costs of Superfund are passed into consumers in the form of higher prices, and therefore estimate consumer surplus losses, and how much are pased on to stockholders or input suppliers. But inadequate data, complex market relationships and methodological uncertainties interact to limit the accuracy and usefulness of cost estimates. Although these problems characterize almost any cost assessment for a regulatory program, the different type of incentives in Superfund further complicate the analysis. Predicting the net effect of the liability provisions of the Act on producer behavior is a particularly difficult task. Yet, it is this mix of producer responses that determines not only how much less waste will be produced or more cautious disposal techniques will be applied, but also whether firms will comply with the notification provisions or try to conceal potentially hazardous sites or spills.

Although it is not possible to evaluate all of the specific cost/producer response relationships that are important from the standpoint of understanding the cost elements of Superfund and their impact, two particularly interesting and potentially critical effects are discussed in more detail below. The first looks at the effect of cost changes brought on by the change in liability provisions on market structure. This relationship will determine, in part, the disposal facility capacity shortfall, an issue of current interest at EPA. The second briefly looks at the relationship between compliance costs and the level of compliance. This often neglected interplay ultimately determines one major part of the benefits and costs of regulatory programs and has a significant role in selecting optimal implementation mechanisms.

Types of Liabilities and Changes in Market Structure

To predict the economic impacts on market structure of imposing strict, joint, and several liability it is necessary to determine their effect on the cost functions of relevant firms. Although there may be several types of structural changes, the focus of this section is on the choice of disposing on-site or off-site.[49]

Assume, for simplicity, that the total cost function of a representative firm generating hazardous wastes is given by:

$$(1)\ldots\ldots\ TC = \sum_{i=1}^{n} X_i W_i + YW_y + ZW_z$$

$$\text{with } W_y = f(C_{y,1}, C_{y,2}(\pi_{y,1}, \pi_{y,2}))$$

$$W_z = f(C_{z,1}, C_{z,2}(\pi_{z,1}, \pi_{z,2}))$$

where X_i are the production inputs, other than hazardous waste disposal; Y is the waste disposed by generator; Z is the waste disposed by outside service; W_i are the input prices or unit costs; $C_{i,1}$ are expenditures on constructing and maintaining disposal facility; $C_{i,2}$ are expenditures for health and environmental damages due to improper release of the hazardous wastes (i=y and z); $\pi_{i,1}$ is the probability of improper release (i= y and z); and $\pi_{i,2}$ is the propability of being held liable.

Some of the more important relationships within the function are:

$$\frac{\partial W_{i,j}}{\partial C_{i,j}} > 0 \qquad \frac{\partial C_{i,j}}{\partial \pi} > 0 \qquad \frac{\partial \pi_{i,1}}{\partial C_{i,1}} > 0$$

where $j = 1, 2$

The total cost function includes disposal service as an input into producing a given output, with on-site and off-site disposal services as substitutes. The cost of either service consists of construction, operating and maintenance costs and the expected value of restoration costs and health and environmental damages if the wastes are improperly released. The latter cost is an inverse function of the disposal cost

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element since as disposal expenditures increase, the probability of a release of hazarodus wastes decreases (assuming increased expenditures mean safer sites).

In the absence of Superfund, where high transaction costs limit the liability of irresponsible disposers, assuming on-site and off-site disposal costs are the same, generators may often opt for contracting the disposal to outside services. This is because the probability of being held liable is smaller with outside disposal ($\pi_{y,2}$ was usually smaller than $\pi_{z,2}$); the less the generator has to do with the wastes the better. This conclusion is especially true if the off-site disposer thinks that the probability of being caught and held liable is insignificant, and does not incorporate the expected value of the damages into the price the disposer charges (W_z).

The introduction of strict liability through Superfund causes $\pi_{i,2}$ to increase, since the disposer is responsible for the damages regardless of the amount of care taken. The generator may now be more hesitant to dispose of the waste on-site although the option of using an outside disposer is also less attractive if the likelihood of being held liable is reflected in the higher price. The net outcome (holding all other variables constant), depends on the relative probabilities of being caught, ($\pi_{y,2}$ vs $\pi_{z,2}$).

Joint and several liability introduces the term W_x to the generator's cost function:

$$(2)....TC = \sum_{i=1}^{n} X_i W_i + YW_y + ZW_z + W_x$$

where $W_x = f(\pi_3, C_{z,2})$

π_3: the probability that the party who contracted for off-site disposal is held jointly liable for damages caused by the contractor either because the transporters and disposers cannot shoulder the cost of damages or simply because a court apportionment is made.

The cost of outside disposal is now represented by the last two elements in equation (2).

The damage expenditures, $C_{z,2}$, appears in both parts of the costs of outside disposal. In the first expression, liability influences the price the disposer charges as a risk premium, i.e., the amount the disposer must be rewarded for accepting the risk of a spill or leak. The actual premium is difficult to predict and would depend, in part, on risk adverseness of the particular firm. The second expression shows that damage costs can be a direct cost to the generator under joint liability.

If the generator attempts to minimize costs, the addition of the last term increases the incentive for on-site disposal of wastes, holding all other variables constant. For those firms that have no current on-site capacity, the total costs of constructing, operating and maintaining a site must be compared to the sum of the last two terms in equation (2). If the final decision is to continue to use off-site services, or change the current mix of on-site versus off-site, the generator will seek to minimize the probability of being held jointly or severally liable. This might be accomplished through contract terms that stipulate various proper management techniques or selecting responsible disposers. This will, in turn, increase off-site disposal costs and generate a further incentive to dispose on-site.

It is possible to imagine at least two specific types of responses to the increased incentive to dispose on-site. First, generators can construct new facilities on their own property or expand existing capacity. The fact that most generators have sites adjacent to production sources points to many advantages of this approach such as proximity, complementarity to existing production technology and total control over disposal firms. Such vertical integration can allow the firm to control the entire process of disposal and maintain, if necessary, economies of scale by accepting outside wastes. In addition, it is possible that hazardous waste disposal firms will be forced to horizontally integrate. This might occur if only large firms could put together adequate financial resources to meet potential liability payments or insurance premiums. The importance of this latter element is growing as generators demand that contractors carry insurance to cover spills or accidents.

Of course, the actual effects of changes in the industry's cost function can only be determined empirically. Although it seems safe to assert that the increased costs of disposal (through increased probability of being held liable for a spill or leak) will tend to concentrate the disposal industry and lead to increased on-site disposal, the degree of these shifts is difficult to predict in the absence of good data. While it may rarely be feasible to conduct such a detailed analysis of every regulatory alternative, it is important to understand, if only in qualitative terms, the major interactions that characterize regulatory cost elements.

Incentives to Provide Information

It was suggested earlier that the benefits and costs of Superfund would depend partially on the degree of compliance with the regulations promulgated under the act. Although analyses of regulatory costs and benefits normally assume 100% compliance, there are at least two important reasons for incorporating some assessment of potential noncompliance. A model that allows for less than full compliance will, in many instances, (1) provide a more realistic picture of the likely effects and (2) identify certain behavioral relationships that, if taken more explicitly into account, would result in greater benefits at less cost. The private decision process that will determine compliance with the notification and reporting sections of Superfund is abstracted below and several important issues highlighted.[50]

A firm deciding whether or not to comply with the Superfund notification requirements will compare the private costs and benefits of doing so with the costs and benefits of noncompliance. Simply put, the firm's decision-making process will be:

(3) $C + C_1 + C_2 > \pi (C + C_1 + Pn)$ noncompliance

(4) $C + C_1 + C_2 < \pi (C + C_1 + Pn)$ compliance

where:

C = Damage claims

C_1 = Clean up costs

C_2 = Reporting and notification costs

Pn = Penalties

π = Probability of detection

The left hand side of these relationships represent the costs associated with notifying the government of the existence of a site or a spill occurrence. Assuming that once reported all sites are cleaned up, a complying firm will bear the costs of monitoring, remedial measures, and damage compensation payments awarded through the courts, as well as the notification costs themselves. The right hand sides of (3) and (4) are noncompliance costs and are shown as expected values. That is, there is some probability (π) that failure to comply will result in having to pay clean-up and damage costs as well as a penalty or fine for not complying. Clearly, the decision to comply or not depends, assuming equal clean-up and damage costs in either case, on the probability of being caught and on the level of the fine and penalty. Under Superfund, there is a maximum penalty of $20,000 ($10,000 for failure to notify EPA of the existence of a site and $10,000 for failure to establish an adequate insurance fund) and one year in jail for both offenses. In addition, and perhaps more importantly, violators of Superfund requirements are no longer subject to any limit on their liability.

Equations (3) and (4) provide a rough guide for predicting whether or not an incentive exists to reveal information on waste sites. For example, assume that a firm becomes aware of a hazardous waste spill from one of its disposal sites. The firm knows that it will cost $2 million to control the spill and that damages will be around $500,000. The alternative is to not notify EPA and let the spill remain as is. If they pursue the latter course and are caught they will face, in addition to the cleanup and damage costs, a penalty of $20,000. The point at which the firm will be indifferent between hiding the site or notifying EPA can be determined by substituting these figures into equation (3) and solving for π. In this simplified case, the probability of being caught would have to exceed 0.997 for the firm to have an incentive to reveal information about the site. The reporting and notification costs have not been included in this calculation, but would only serve to buttress the incentive to not reveal information.

A more realistic formulation would allow for the effects of fear of imprisonment, loss of corporate image and increased liability limits. These intangible costs would appear as additional variables on the right hand side of equations (3) and (4). Depending on their relative size they could tip the balance between compliance and noncompliance. Although data on the likely value for these effects is not available, cost data from several hazardous waste dump site case studies, presented in appendix B, can be used to illustrate the general concepts outlined here and give same idea of the relative magnitude of the intangible costs that is necessary to shift a firm from noncompliance to compliance.

Table I presents clean-up costs and damage compensation payments, where available, for 4 hazardous waste sites. As in the previous hypothetical example these costs can be substituted into equations (3) or (4) to solve for the detection probability (π) that would make a firm indifferent between revealing information on a site (again, reporting and notification costs are not included and the maximum fine is assumed to be $20,000). For all 4 sites the probability of being caught would have to exceed 90%, an unlikely level, for the firm to come forward with information on the site. A lower, more realistic probability would, of course, only strengthen the case for noncompliance. If one assumes a lower value for π, for example, 10 percent, these cost figures can be used to estimate the dollar value of the aggregate intangible cost elements necessary to tip the balance in favor of compliance. Remembering that the intangible costs can be represented by an additional variable within the right hand side parentheses of equations (3) and (4), they can be solved by substituting in the assumed detection probability and for the cost figures from Table I. Making these calculations, the costs of lost corporate prestige, jail terms and increased liability would have to be valued at a low of \$2.5 million in the Dover, N.J. case to over \$28 million in the Bullit County case to lead to compliance.

It should be clear that the cost figures and calculations used in these examples provide only a very rough gauge with which to judge the incentive structure of Superfund. Additionally, the compliance model itself abstracts from reality in several important respects. Most notable, a large percent of individuals and companies comply with the law even though a strictly rational decision model would suggest otherwise. Nevertheless, the model serves several important purposes.

TABLE I: COST ASSOCIATED WITH HAZARDOUS WASTE INCIDENCES: SELECTED CASES

			Compensation for	
Case	Chemical	Volume	Clean up Cost ($)	Health and Environment Damage
Bullitt County, KY	Organic Compunds	17,006 drums	3,148,000	*
Chester, PA	Hazardous Materials	50,000 gallons	1,250,000- 3,000,000	*
North Carolina	PCBs	30,000 gallons	1,580,000	*
Dover, NJ	Organic Chemicals	5,500 barrels	49,350	210,000

* Not quantified

First, it demonstrates the possible strong incentives for the private sector not to comply with Superfund reporting and notification requirements.

Second, the model provides a crude method by which the level of compliance can be more explicitly taken into account in regulatory policy analyses, assuming data on the cost and probability elements (the latter, of course, could be subjected to sensitivity analysis to determine its importance).

Third, it highlights the critical role played by other policy control variables, which though carefully considered by Agencies, are not often made part of a formal analysis. Certainly, a more complete and realistic analysis would provide for simultaneous manipulation of the standard level, fines, penalties, and the enforcement level to design optimal regulatory programs.

Fourth, and finally, the compliance model suggests alternative means of structuring the requirements of Superfund that would meet the goals of the Act at potentially lower costs. This might include, for example, placing strict limits on the liability of disposers who comply (lowering the private costs of compensation and clean-up) or using economic incentives to induce owners or operators of sites to voluntarily reveal information (this option actually adds a negative cost element to the model, offsetting the positive costs).

Of course, these alternatives would have to be judged in a cost/benefit analysis to determine if the costs of the incentives to the government or society are offset by increased compliance and therefore greater damages avoided or benefits.

SECTION VI

SITING OF HAZARDOUS WASTE MANAGEMENT FACILITIES

INTRODUCTION

The siting of hazardous waste facilities is currently one of the most significant obstacles to proper hazardous waste management. A sufficient quantity of treatment, storage, and disposal capacity for hazardous wastes is critical for proper waste management as well as for the success of current government hazardous waste regulatory programs. However, recent attempts to site hazardous waste management facilities have been rebuffed by an alarmed public. Public opposition to hazardous waste facilities poses a serious obstacle to meeting the increasing industrial and municipal demand for these services. A study for EPA, completed in 1979, concludes that "public opposition to the siting of hazardous waste management facilities, particularly landfills, is a critical problem."[52] If a shortfall of new facilities occurs, generators may be forced to dispose of their wastes at older, inadequately engineered facilities or to dispose of their wastes illegally. If this occurs, the proper management of hazardous wastes and the protection of human health and environment desired by Congress will be jeopardized.

Both federal and state governments have become concerned about the possibility of a shortage of hazardous waste facilities. Many government officials and facility developers believe that because the private marketplace is incapable of allowing adequate new hazardous waste facilities to be sited, some form of government intervention is necessary. While EPA has decided not to intervene, states have begun to facilitate the siting process through the use of various strategies. One such strategy adopted by several states is to preempt the right of the potential host community to reject the siting through local ordinances.

The purpose of this section is to define the siting problem and to use the economic framework developed in previous sections to examine the need for a government presence in the siting of hazardous waste facilities. Two issues will be addressed: 1) the justification for federal or state government intervention, and 2) the most effective types of government

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intervention for siting hazardous waste facilities. In analyzing the first issue an evaluation of the role of transaction costs and the possibility of the government acting as a beneficiary is addressed. In analyzing the second issue a cost/benefit analysis framework will be used to evaluate alternative intervention schemes.

The lack of adequate data on variables such as the cost of siting facilities and the cost of potential health and environmental risks associated with such facilities limits this analysis to qualitative observations. While this is obviously less satisfactory than a thorough quantitative analysis of the costs and benefits of facility siting, a qualitative analysis does allow for the identification of alternatives facing policymakers. Presenting these alternatives in a cost/benefit framework provides a balanced and comprehensive view of policy alternatives so that policymakers can carefully consider and clearly understand the aggregate social impact of each alternative before it is implemented. In this regard this section establishes some of the critical boundaries that would define a more formal and rigorous analysis.

THE SITING PROBLEM: PUBLIC OPPOSITION

One of the primary obstacles to expanding hazardous waste management capacity is local public opposition to the siting of new facilities. Facility developers often find it difficult to obtain the necessary development permits in the face of public opposition to the potential risks posed by a site. Tactics employed by residents and local officials to block, bar or slow construction of hazardous waste facilities include using the public hearing process to show political influence, threatening or initiating law suits, developing technical arguments against a proposal, and changing land use ordinances.[53] Regardless of the specific form of public opposition, they are all evidence of a deepseated concern over hazardous waste facilities on the part of the public. Some of the more important elements underlying this public response are briefly described below.

Public Fear

In seventeen case studies involving public opposition, citizens cited a fear of becoming a "dumping ground," and experiencing adverse health effects and natural resource damage. The public may view a site as a future Love Canal, refusing to trust technologies minimizing public health risks. Fear of mismanagement and possible accidents during transport and storage phases also plays a major role in motivating public apprehension. Finally, the public fears impacts such as decreased local property values and a depressed local economy from having a hazardous waste facility located in their neighborhood.

Geographical Inequity

Local opposition to the siting of a hazardous waste facility may be aroused by a feeling of unfairness toward the geographical location. Often the public believes the most appropriate location for a waste facility is in the area which generates the wastes, the underlying factor being a feeling of inequity in having to shoulder the burden of another locality's or state's hazardous wastes. Local residents may believe alternative locations are safer. Such a rationale may be based on geologic or hydrological data on the site which introduces uncertainties of the site's safety or a general bias that any alternative is preferable to one's own neighborhood.

Mistrust of Hazardous Waste Management Businesses

Mistrust of hazardous waste business spurs local opposition in several ways. Learning that the facility sponsor has been associated with health and environmental damages elsewhere increases the public's skepticism of the facility's safety even when the type of operation is very different from the one which caused the damage. Incidents of releases and spills have increased public concerns to the point that citizens do not believe evidence presented by facility sponsors demonstrating the relative safety of a facility or that the wastes to be handled by the facility are relatively innocuous.

Community Alienation

Community alienation may result when local residents perceive their interests to be unrepresented, or misrepresented, during the hazardous waste facility approval process. Frequently, community leaders are given only an advisory role or have only minority representation in the permit approval process. Lacking representation, citizens believe that their interests are compromised by the decisionmakers. Such local feelings may generate highly emotional opposition.

ANALYSIS OF THE SITING ISSUE

Strong public opposition poses the most difficult obstacle to the siting of hazardous waste facilities. To examine this problem and the extent to which the government can intervene, the siting issue can be defined in terms of a simplified cost/benefit framework, similar to the analysis presented in Section III. This definition will permit a clear analysis of the role that governments can play in siting hazardous waste facilities.

A Conceptual Framework

The real issue of adequate hazardous waste capacity in the face of public opposition is the allocation of the right to construct, expand and operate such a plant. Even though a firm might own the land on which they propose to site a facility, the public or a local government entity can attempt to thwart development by asserting their right to control what substances are placed in their community, and how the placement is carried out. This siting right is traded in different ways such as through the courts, the political process or more informal discussions between a town and facility developer.

In some respects, the siting right is like a private good; one developer's consumption of it decreases the quantity of sites available to other developers and excludes them from using the right. A developer has an incentive to compensate communities (buy the right to site) as long as this cost can be covered by the revenues from waste disposal.

The consumers of the site or the right to site are the developers, and the suppliers of the right are the local communities. On the demand side, need for siting is derived from the demand for disposal services, which in turn depends on the level of industrial production that generates the wastes. Sites for hazardous waste facilities are an input to disposal services. The willingness-to-pay of the disposer is the maximum price he/she is willing to incur for the right to site a facility. The supply of the site is derived from the local community's willingness-to-sell the right for siting. The willingness-to-sell is the minimum amount of compensation that will make the community indifferent to the siting. If the community's willingness-to-sell the site equals the developer's willingness-to-pay, a trade beneficial to both sides occurs.

The need for economic compensation in siting locally undesirable facilities has long been recognized as a component of siting tactics. In Michael O'Hare's article "Not On My Block You Don't," O'Hare argues that "an important failing of current practice in siting a facility is the strategic problem that results from failure to pay compensation to neighbors who suffer costs not found to be a 'taking' under law."[54] In the past compensation was implied by local employment and tax revenue to be generated by the facility. Explicit forms of compensation, such as subsidy to local treasury or construction of local public facility was considered as "bribery" and generally avoided. Besides such image problems, the economic incentive approach faces other serious shortcomings such as information requirements, political process of determining the willingness-to-sell and income redistribution effects. Nevertheless, most of these shortcomings can be addressed as policymakers gain more experience in using economic incentives as a siting tool.

Finally, willingness-to-sell on the part of the communities consists of two components: 1) the expected value of damages resulting from the siting; and 2) a risk premium. The second component arises because most of us are risk averse.[55] This component is especially important because risk from the operation of a hazardous wste facility often eludes accurate assessment. Being risk averse, the community needs to be compensated for taking the risk, as well as for the expected value of damage.

JUSTIFICATION FOR GOVERNMENT INTERVENTION

Transaction Costs

Within the economic construct presented here, a role for government in facilitating the transfer of siting rights requires a valuation of whether or not the current allocation system is working and willingness-to-pay and sell are being equated at the margin. In other words, if the legal, political and other public participation programs through which siting right transactions presently occur, do not accurately reflect the desires of suppliers and consumers of the right, a role for government may be necessitated. Government then could intervene through an appropriate mechanism to redress the causes of the imperfection and substitute an alternative trading mechanism.

The existence of burdensome transaction costs may be one major reason for ineffective functioning of the transfer mechanisms affecting siting. In the broadest sense, several categories of costs can be identified that would work to inhibit trades. First, the costs of obtaining relevant information on, for example, the geophysical characteristics of a site, the health and environmental risks posed by a site and, more generally, the willingness of the parties to buy and sell could prohibit meaningful bargaining. Second, the costs of bargaining itself could act to thwart rights transfer negotiation. This would be particularly true if some of the trading mechanisms mentioned earlier do not exist in a specific case (e.g., no opportunity for public hearings) or in an attempt to negotiate through court proceedings. Third, costs associated with ensuring enforcement of the terms of the bargain (for example, a requirement that the developer will conduct monthly safety inspections of the plant) may be so high, or perceived to be so high, that no party sees their best interest being served by entering into a trade.

These three classes of costs do not represent the entire range of transaction costs with the potential to affect rights transfer. Further, the relative importance of these and other costs in influencing trading mechanisms can only be determined on a case by case empirical basis. Nevertheless, they provide sufficient reason to question the effectiveness of the existing transfer mechanism to equate marginal willingness-to-buy and sell. Ineffective transfer mechanisms could lead to too few and too many hazardous waste sites, although it is difficult to say in which direction the bias will be.

In order to examine the direction of the bias it is necessary to investigate the effects of transactions costs more fully. There are at least two cases (subject, of course to empirical verification) where transaction costs would inhibit the production of hazardous waste management capacity.

First, the willingness-to-sell of the communities can be inflated. The community's price for the right to site hazardous waste facilities is defined by the expected value of damages and a risk premium. If the community's assessment of the risks from a specific plant overstates the actual risks, both elements will be overestimated, resulting in too few sites. The costs of collecting and assimilating information on the risks of alternatives, complex and often new disposal technologies would lead to such a situation if in the face of these costs, the public bases their risk estimates on past disposal practices and technologies.

This historical perspective would suggest inflated risk estimates in spite of the extensive new regulations promulgated under RCRA. Even if the public perceives the RCRA regulations as lowering the risks of facilities, they may still base their risk assessments on historical trends if they doubt the ability of government to effectively enforce the standards.

Second, willingness-to-pay of the developers can be underestimated. Even if willingness-to-sell is accurately reflected within the trading mechanism, the developer or disposal facility owner may not be able to express accurately their willingness-to-pay for siting rights. This distortion can be explained in several ways. Developers may engage in strategic bidding behavior if they feel that by initially offering a low price for the right, the existence of transaction costs will work in their favor. Alternatively, the communities may request exaggerated payment from the developers. Where bargaining costs are prohibitive, negotiations may never reach the point where more realistic bids and offers can be equated. Also, it is likely that an avenue through which willingness-to-pay can be expressed may not be available; the lack of bargaining forums can work against as well as for the developer. Finally, the developer may not be aware of the level or type of payment that the public would accept for a siting right and, as a result, make inadequate offers. Transaction costs again would lead to this outcome if existing mechanisms for trade limited the ability of the public to express their concerns and fears. For example, a developer might offer compensation in the form of a park abutting the site, when the public's real concern is assuring the safety of the site; in such a situation the developer may have been willing to offer more had it been aware of the public needs.

The above analysis suggests that impediments exist in the siting right trading mechanism. Such impediments lend justification to government intervention to reduce the transaction costs of trading siting rights between communities and developers. In general, the government should reduce transactions costs if net benefit can be realized at least cost. Benefits will result from increased trade through, for example, provision of information[56] (e.g., economic statistics) or a forum of exchange (e.g., Security Exchange Commission). However, in this case the government also has to argue that the private marketplace does not provide enough of such service to reduce the transaction costs, or that it will be more costly for the private marketplace to produce the same services.

Such a situation occurs when it is difficult to exclude non-paying users of a service. For example, private producers are discouraged from offering a socially desirable level of a service, such as information on the risk of hazardous wastes, because compensation cannot be collected. It is useful to further illustrate this point.

Information on the potential health and environmental hazards of hazardous waste facilities is a public good which could substantially reduce the transaction costs in siting. Toxicological data, for example, is not specific to an area and is very expensive to develop. An animal test on a single chemical can cost $300,000. Clearly, unnecessary expense and redundancy will result if individuals or each state develop toxicological information. The federal government already possesses centralized information on substances that can be readily used in siting. Data banks on toxic substances, exposure records, and other information on generation and disposal of hazardous wastes can be used to reduce the uncertainty surrounding the risks associated with facilities during negotiations between the developer and the community. The public benefits from the information do not encourage a

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developer to provide the information, since the private benefits may be less than the costs.

There may also be a role for government in reducing transaction costs through institutional arrangements. For example, the permitting process for siting hazardous waste facilities could be streamlined to allow the developer to avoid delay and provide a forum where the interests of the various participants can be more easily identified and necessary compromises made without lengthy court actions. Government could also prepare a list of geologically safe sites to narrow down the search cost of the developers. An extreme example of reducing transaction costs is the use of preemptive authority to override objections of the local communities. Again, the extent of government action is determined by the benefits and costs of the alternative arrangements; do the benefits of preemptive authority outweigh the costs?

Government as Beneficiary

There are times when government intervention results in an increase in its economic or political base. This is especially true on regional or state level where industrial activities produce tax revenues and employment. A hazardous waste facility in a locality supplies treatment and disposal capacity to generators dispersed over a larger area than that absorbing the facility's risks. Although the locality benefits from the facility development to the extent that new jobs and a broader tax base are provided, they are also made available to a much wider region. A state government is more likely to consider the larger area benefited by a facility, and absorb the transaction costs of developing and communicating information about the facility to the residents of an affected area.

In addition, if no nearby facilities are available, hazardous waste generators may have to transport their wastes long distances for treatment and disposal. This practice imposes high transport costs and a greater risk of hazardous waste transport spills. An industry deciding where to locate a plant will consider the cost of hazardous waste disposal at each potential location. It will prefer, all other things being equal, areas offering low-cost hazardous waste disposal, which will probably be areas where a facility will be close to the plant. Regions without hazardous waste facilities may eventually lose industries generating waste thus reducing the state's employment and tax base. An interesting example of the crucial role hazardous waste facilities can play in attracting industry involves an Allied Chemical plant in Baltimore, Maryland that threatened to move out if no landfill site was established for the plant's chemical wastes.

Because of these benefits from the operation of hazardous waste facilities, states have an active interest in facility siting. However, this interest is offset by their concern for the health and environment of the state. Thus, states often seek to facilitate siting by reducing the transaction costs while protecting the residents near the site. State governments can accomplish this goal by providing information on various aspects of hazardous waste management, such as geological and hydrological characteristics of the sites, types of wastes that are to be disposed, past performance of the developers, and economic impact on the communities. States may also attempt to improve the environment for negotiation through providing neutral parties such as local university scientist and professional mediator.

Summary

The discussion so far has focused on the important economic considerations that define and limit the activities of governments with regard to siting of hazardous waste facilities. It was argued that while mechanisms for transferring the right to site a facility exist, transaction costs may limit their effectiveness in equating demand and supply. Further, there appear to be sufficient reasons to assume that as a result, trades are biased towards too little hazardous waste facility capacity. Although the presence of transaction costs was seen as an appropriate justification under certain situations for government actions, externality theory did not. Finally, economic benefits to states or regions were identified as another basis for government action. It should be noted, though, that in a strict sense this justification does not rest on an economic rationale, but is rather politically motivated.

Given this background, it is now possible to identify some alternative government actions that address the problems noted above and briefly review these within a cost/benefit framework. Before this, it is necessary to address the issue of what level of government should respond. Both federal and state governments can reduce transaction costs. The following discussion on siting policy alternatives, though, focuses on state level actions. There are two major reasons for viewing the analysis from this perspective. First, to the extent that the state is the chief beneficiary of efforts to facilitate the trading of siting rights, they should bear the costs. Second, the states are generally in a better position to develop responses that are compatible to local needs or responses that affect their own industrial development. This view does not minimize the important role for the federal government in setting uniform safety standards and providing information that has nationwide uses. The theory and practice of this latter has already been well established elsewhere.[56] Finally, this perspective fits the current federal siting strategy which leaves most of the decision making to the states.

ALTERNATIVES FOR STATE GOVERNMENT SITING POLICY

State governments are taking active roles in managing hazardous wastes through a varied set of regulatory programs.[57] Their concern about the availability of management capacity is based on several considerations. First, state governments understand that lack of management capacity will lead to improper handling of hazardous wastes which in turn will threaten the residents' health and the states' environmental resources. Indeed state agencies, such as departments of natural resources and health, actively monitor the handling of hazardous wastes. Second, states are concerned that industrial establishments find adequate management capacity for the wastes they generate. Since waste disposal is an integral part of industrial production processes, the performance of the states' industries will be affected by the availability of waste management capacity. Third, states are aware that some industries are attracted to locations where proximity to hazardous waste facilities minimizes costs of transporting their hazardous wastes.

In attempting to reduce the transaction costs between developers and communities a state government can select among various policy intervention measures. Direct intervention measures, such as government ownership of the sites or preemption of local zoning authority, directly replace the marketplace in determining the optimal level of siting or transfer of siting rights. Instead of relying on the supply and demand of sites as discussed in the conceptual framework, the state makes the allocative decisions. The measure is effective in reducing transaction costs since the communities can no longer delay the siting and, in essence, now enter into an involuntary trade. Indirect intervention measures do not in themselves allocate siting rights. However, they do influence the resulting outcome of the trade depending on the initial direction of bias. For example, providing information on the risks of the wastes reduces the transaction costs to the developers and subsequently increases the developers' gain from the trade.

The decision on which type of measure to use should follow the criterion that costs to the government be less than the benefits accrued by the public. Thus, cost/benefit analysis can be a useful selection guide. Without actual data on the costs and the benefits of the measures, quantitative cost/benefit estimation cannot be derived. However, this section will identify some of the cost/benefit elements and show how they can be organized to aid decision-making.

Direct Measures of Intervention

State governments can directly intervene in the siting process to assure the availability of sites for additional hazardous waste facilities through central planning supported by either owning and leasing the sites or using preemptive siting strategy. Because the benefits and costs of the two measures are essentially the same, they will be discussed together after a brief description of each alternative.

Government Ownership--

Under this option, the government would first identify geographical areas where a shortage of hazardous waste facilities exists and then either develop facilities on state owned land or simply buy the appropriate site. The choice has to consider the pattern of industrial waste generation, population density, critical environmental areas, transportation systems and regional and local economic impacts. Once the site is available, the state can either establish and operate the facilities or lease the site to disposers. In the former case, the government would be the producer of disposal services. However, it is more likely that the land will be leased leaving the development and operation of the facilities to the private sector. The identification of costs and benefits will be based on this latter assumption.

Preemptive Siting Authority--

In an effort to streamline the siting process some states have developed siting boards which are authorized to preempt the host community's right to reject the siting. An example is Michigan, which passed a comprehensive act for statewide management of hazardous waste in 1979. The Act is often cited as a model for state siting authority because it established a facility site review board with final permit review and preemptive authority over local land use and zoning ordinances.[58] The board does not participate in the state hazardous waste management plan or in the initial site selection process. It is insulated from management activities in order to insure unbiased decisionmaking and prevent a conflict of interest between acting as regulator as well as developer. The Michigan Act embodies several key elements in resolving the siting problem. It requires that the siting board be composed of nine members; three are permanent representatives from state agencies and two are scientists with technical expertise in geology and chemical engineering. All permanent members must be appointed by the governor. In addition, four _ad hoc_ members represent local interests. Local representatives must be appointed by the local community or

County Board of Commissioners in the jurisdiction of the proposed facility.

Since Michigan's 1979 Act, other states including Tennessee, Pennsylvania, and Maryland have established siting boards with preemptive authority. However, because these siting boards are so new, none have yet made a siting decision. Therefore, the effectiveness of a board's preemptive authority over local zoning has not been tested.

Costs--

The costs of government undertaking the direct intervention measures of government acquisition of land or preemptive authority over local ordinances are the following:

Land (not included under preemptive siting)--The cost of the land can be either its market price when the land is acquired or the implicit value when the land already belongs to the government. The implicit value should reflect the opportunity cost of the and, i.e., value to users who will be deprived of the uses once the facility is established.

Administrative--Costs of the ownership option can be divided into: 1) selecting the site, including surveying geophysically physical constraints, identifying location and the amount of wastes generated; 2) arranging the purchase if the land is not owned by the state; 3) leasing the land to developers; and 4) administrating the leases. For the preemptive siting option the costs are: 1) establishing the siting authority; 2) surveying and judging the proposal sites; and 3) implementing the preemptive authority.

Inefficiency--Direct measures replace the allocative functions of the marketplace with a centralized allocative plan. If the central plan misjudges the social demand and supply of sites there will be a loss in allocative efficiency. This occurs, for example, if the state presuming that excess demand for additional siting of exits, sites a new facility only to later find the facility is not able to cover its costs, or misjudging the level of public opposition to the siting, the new facilities are shut down by continuous harassment. In this case valuable resources (e.g., the land used for the site) could have been used for other socially desirable activities. The reduced opportunities result in loss of efficiency in terms of foregone consumption and production of the activities. The misjudgment can also cause income distribution impacts, such as loss of employment. The extent of inefficiency on the part of the state government is impossible to measure beforehand and is often left out of actual cost/benefit calculations, assuming the efficiency effects are negligible and the consequence of ignoring this cost component is not serious.

Benefits--

Health and environmental risk--The benefits of any siting program are represented by damages to public health and environment that are avoided. This follows from the government's concern that an ability to site new facilities may result in damages to public health and environment due to lack of disposal services. Although conceptually simple, measuring the damages avoided by new siting is complex. The primary problem is to assess the hazardous waste releases that are caused by lack of management capacity or high prices of disposal services. Ideally, one hopes to identify the relationship between the level of excess and the likelihood of harmful releases, holding all other variables constant. For example, Figure I portrays one possible form of this relationship.

Hypothetical Relationship between Excess Capacity
and Likelihood of Harmful Releases

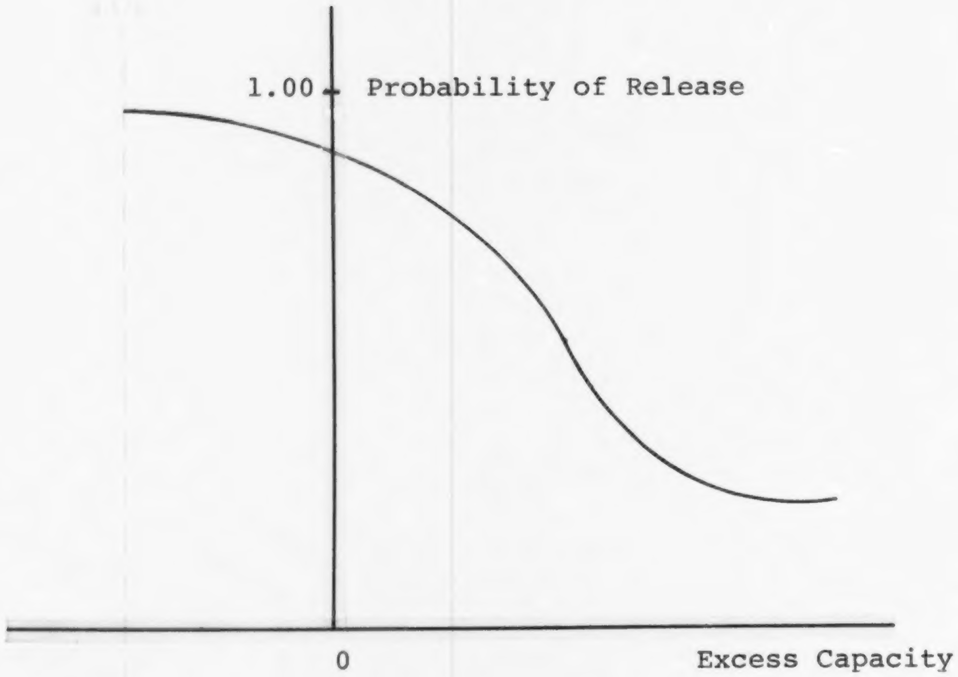

Figure I

The marginal benefits of siting facilities come from the reduction in the likelihood of releases. The level of benefits from a new siting depends on the level of existing capacity; benefits increase as excess capacity approaches zero. When excess capacity becomes excess demand (in the lefthand-side quadrant), the benefits peak. Thus, identifying the level of excess capacity at the time of developing additional hazardous waste facilities is crucial.

The benefit analysis also shows the relationship between benefits and the price of disposal services. Decisions on whether to handle waste legally depends on the costs of complying with the RCRA regulations, one of which is disposal costs. Moderate variation in disposal costs is not likely to precipitate substantial noncompliance. However, as the waste management industry reaches full capacity, large increases in disposal costs may push firms into noncompliance resulting in decreased benefits.

Industrial activities--Another source of benefits is the increase in the states' industrial activities brought forth by the siting measures. For example, if the direct alternative provide the waste management capacity needed to sustain or expand the states' industrial activities, the surplus of these activities should considered as benefits. The level of the benefits depends on how sensitive the industries are to the availability of facilities. For instance, if the states' industrial activities are service oriented, such benefits will be negligible. The level will also depend on the neighboring states' hazardous waste management attitude, their desire to compete for the location of the same industries and the cost of transporting the waste across state boundaries. It should be noted that industrial activity increases are not benefits in a strict economic sense, but may be important to a specific states' accounting of benefits.

Indirect Measures of Intervention

In the siting framework presented earlier, high transaction costs were shown to be a major obstacle to trade between developers and communities. This suggests that instead of replacing the marketplace mechanisms through direct intervention, governments can complement the marketplace by reducing these costs and facilitating trade between host communities and developers. For example, if the government could assist communities in obtaining the information necessary to reduce uncertainties and provide a forum to negotiate for adequate compensation, more siting attempts might be successful. States can absorb the cost of providing the communities the information necessary to accurately estimate their willingness to sell and developing other types of information which require large scale economies to produce.

The selection of potential alternative schemes would follow directly from the type of analysis presented earlier in this section where the various kinds of transaction costs were identified. Of course, states would need to understand the specific requirements of a general region on a particular site to determine what types of transaction costs are most limiting. These could include: information programs on risks and technologies; establishment of mediation services; the state acting as the enforcer of developer/community contract terms; or identification of likely, safe sites. The expected result of these programs is to allow participants in trading siting rights to more accurately express their willingness-to-pay or sell.

As in the case of direct intervention measures, the type of indirect technique selected and the extent to which it is applied is ultimately determined by a comparison of its costs and benefits. Some of the more critical elements are discussed below.

Costs--

The costs of the indirect measures differ slightly from the costs of the direct measures. Because the government does not own the sites, the land value component is not relevant. For the same reason the bulk of the administrative costs discussed above can also be saved. Further because indirect measures do not replace the allocative function of the marketplace, there should be no efficiency loss due to demand and supply misjudgments. Of course, some administrative costs remain in generating and providing information and support services for facilitating negotiations or enforcing contract terms.

Benefits--

The benefits of the indirect approach, the same as the direct approach are: health and environmental damages avoided through additional siting of facilities and surpluses from increased industrial activities due to added capacity. However, the level of the benefits is difficult to determine since the number of sites is ultimately left to the private sector to decide. The question is: how many facilities will be sited through voluntary trade where the government provides the necessary information and negotiation forum? This will in part depend on the risk preference function underlying the host communities. Given full information communities will have varying responses in terms of their willingness to accept a certain level of risk to their health and environment. Some communities are simply not price or compensation responsive and they will refuse siting at any price. While others, once they possess enough information, will quickly trade with the developers. Another crucial element is the willingness of the developer to pay for the siting. Depending on the demand for disposal services facing the developers, the developers will have varying degrees of ability to meet the level of compensation set out by the communities. If the developers cannot cover the cost of compensating the communities through future revenue, trade will not occur.

Conclusion

Without empirical information the actual comparison of the cost/benefit ratio between direct and indirect measures cannot be made. This analysis merely identified some of the important cost and benefit elements of the two approaches in qualitative terms and has examined some of the underlying assumptions of the analysis.

It is possible that gross benefits from the direct siting measures will exceed the gross benefits from the indirect measures that reduce transaction costs. Siting facilities on government property circumvents the primary obstacle of public opposition because local zoning and other land use ordinances cannot impede the siting process. The direct approach will also produce a higher level of benefits since with the ability to quickly expand disposal costs are likely to be lower. The lower costs will encourage more generators to properly handle and dispose the hazardous wastes, resulting in less risk to the public health and environment. On the other hand, decisions concerning the allocation of public funds must be made on the basis of net benefits and, there fair costs must be considered.

The direct measures will probably be more expensive due to the value of the land to be used as sites. On the other hand, it is not clear whether the indirect measures will incur more costs in gathering information and facilitating negotiation than the direct measures in devising and implementing a centralized siting plan. This will depend on the comprehensiveness of the plan. Ideally, the plan should consider all the relevant factors underlying the supply of and demand for facilities and provide the optimal number of sites based on a socially desirable balance between risk to public health and environment and need for waste management capacity. The costs of developing the plan will depend on the government's desire to approximate such a balance.

A hidden cost perhaps substantial enough to tip the balance in favor of indirect measures is the potential efficiency loss of the direct approach. Too many or too few sitings will distort the optimal social allocation of resources and result in consumer or producer surplus losses. Further, misinvestment in new facilities can cause painful struggles for both the community and the developer. When the community's preference is estimated incorrectly, the cost can be found in all forms of local opposition after the facility is sited, such as protests, court actions, strikes, shutting down the facility, and even violent disruptions throughout the community. Such a cost, although occurring after the siting, should not be ignored.

Efficiency losses are a very real possibility with direct intervention measures as the state's role of deciding whether the risk level of operating the facility is acceptable to the residents. The divergence between those who make the decision and those who suffer the consequences of the decision creates a new externality that can result in significant social costs.

In the final analysis the policymaker has to balance all the costs and benefits to select the most appropriate alternative. It is clear that even with improvement in data, not all of the costs and benefits will be quantifiable. Unlike deciding whether to build a dam, choosing a hazardous waste siting policy cannot rely totally on cost/benefit analysis. However, the application of the cost/benefit framework can help the policymaker sort out interrelated factors, identify uncertainty, and choose a policy whose impacts are understood and accepted.

FOOTNOTES

SECTION I

1. U.S. EPA, Damages and Threats Caused by Hazardous Material Sites, Oil and Special Materials Control Division, Wash. D.C., May 1980.

2. Ibid.

3. Federal Register, May 19, 1980.

4. Environmental Protection Agency, supra. note 1.

5. Ibid.

6. Congressional Research Service, Six Case Studies of Compensation for Toxic Substances Pollution: Alabama, California, Michigan, Missouri, New Jersey and Texas, Washington, D.C., 1981.

7. U.S. Environmental Protection Agency, Preliminary Assessment of Cleanup Costs for National Hazardous Waste Problems, prepared by Fred C. Hart Associates, 1979.

8. Congressional Research Service, Library of Congress, Resource Losses from Surface Water, Groundwater, an Atmospheric Contamination: A Catalog, March, 1980.

Section II

9. Executive Order 12291 requires agencies to maximize net benefit in selecting regulatory goals.

Section III

10. See Demsetz, H., "When does the Rule of Liability Matter?" Journal of Legal Studies, 13 (1972) and Calabresi, G. and A.D. Melamed, "Property Rules, Liability Rules and Inalienability: One View of the Cathedral," Harvard Law Review, 1972.

11. Clearly, this will depend on the original distribution of wealth among the entitled and unentitled parties. Although the final allocations may be different, given an initial distribution of wealth, it will be efficient.

12. Rodgers, Environmental Law (West: 1978), p. 102.

13. For example, the defenses of estoppel, prescriptive rights, and laches are not available. Those defenses generally prevent one from enjoining an activity (i) which has been encouraged or accepted by the injured party (estoppel); (ii) which has continued over a long period of time with knowledge and acquiescence of the injured party (prescriptive rights); or (iii) which has not been contested by the injured party in a timely fashion (laches).

14. Standing defines who has the right to sue.

15. The judge does the balancing in a non-jury trial; whereas the jury does the balancing in a jury trial.

16. *See*, *e.g.*, Harrison v. Indiana Auto Schredders Co., 528 F.2d (7th Cir., 1976) at 1122-23.

17. Note that even under a strict liability nuisance theory, the activity is not automatically enjoined. The activity could continue as long as those injured are adequately compensated.

18. Supra., Footnote 4, provides several examples of and problems in compensation cases involving toxic substances in Alabama, California, Michigan, Missouri, New Jersey and Texas.

19. Dablman, C.J., "The Problem of Externality," *The Journal of Law and Economics*, 22 (1979).

Section IV

20. For a complete review of the economic theory underlying benefit analysis and estimation techniques see: Freeman, A.M. III, *The Benefits of Environmental Improvement*, (Baltimore: Johns Hopkins, University Press, 1979).

21. For an interesting treatment of common biases in the interpretation of statistical information see: Fischoff, B., P. Lichphtenstein, "Weighing the Risk", *Environment*, Vol. 21, May 1979, p. 17-38.

22. U.S. Environmental Protection Agency (Office of Air Quality Planning and Standards). A method for Assessing the Health Risks Associated with Alternative Air Quality Standards for Ozone. (Draft) July 1978.

23. See: Lave, L.B. and E.P. Seskin, *Air Pollution and Human Health*, (Baltimore: Johns Hopkins Press, 1977) and Brookshire, D.S. et al., *Methods Development for Assessing Air Pollution Control Benefits*, (Washington: U.S. EPA, 1979 600/5-79-001 a-e).

24. Decision analysis and other policy tools are described in Stokey, E. and R. Zeckhausen, *A Primer for Policy Analysis*, (New York: W.W. Natan and Co., 1978).

25. U.S. Nuclear Regulatory Commission. *Reactor Safety Study*. USNRC report (NUREG-75/014). WASH-14-0. October 1975.

26. A general review of some of the technological uncertainties associated with benefit analysis is found in: Dower, R.C. and D.C. Maldenado, *An Overview: Assessing the Benefits of Environmental, Health and Safety Regulations*, (Washington: U.S. Regulatory Council, 1981).

27. Ben-David, S., A.V. Kneese and W.D. Schulze. *A Study of the Ethical Foundations of Benefit-Cost Analysis Techniques*, Resource Economics Group, University of New Mexico, Working Paper, August 1979.

28. 29 U.S.C. § 655(b)(5) (1970).

29. Committee on Interstate and Foreign Commerce (U.S. House of Representatives). *Waste Disposal Site Survey*, Print 96-IFC 33, October 1979.

Section V

30. Douglas M. Costle, *Foresight vs. Fear: Learning the Right Lesson from Love Canal*. Portland, Maine: Remarks prepared for the Maine Hazardous Waste Conference, May 30, 1980.

31. Durwood Zaelke, Attorney, Land and Natural Resources Division, U.S. Department of Justice. *Materials for Workshop on Investigation and Control of Hazardous Waste Sites*. Prepared for a workshop at the National Enforcement Investigations Center, Denver, Colorado, April 30 - May 2, 1979.

32. 33 U.S.C. § 1251.

33. 42 U.S.C. § 6901.

34. The Need for Additional Legislation on Hazardous Chemicals: Hearing on H.R. 85. Before the Water Resources Subcommittee of the House Committee on Public Works and Transportation, 96th Cong., 2d Sess. (1980) (Statement by Kenneth S. Kamlet).

35. U.S. Senate Committee on Environmental and Public Works. Environmental Emergency Response Act. Report No. 96-848, Washington, D.C.: U.S. Government Printing Office, July 11, 1980.

36. 33 U.S.C. § 1364.

37. Comprehensive Environmental Response, Compensation and Liability Act § 104(a)(1)(B).

38. CERCLA, § 104.

39. 26 U.S.C. 4611, 26 U.S.C. 4661.

40. S. 1480.

41. See Testimony by Rep. Florio, Congressional Record, Dec. 3, 1980, p. H-11 781.

42. CERCLA, § 107(b).

43. "Superfund - How It Will Work, What It Will Cost," Chemical Week, December 17, 1980, pp. 38-41.

44. See, Testimony by Rep. Florio, Congressional Record, December 3, 1980, p. H-11787; and Letter by Alan A. Parker, Assistant Attorney General, U.S. Department of Justice, Congressional Record, December 3, 1980, p. H 11788.

45. Ibid.

46. CERCLA, § 103(d).

47. Calabresi, Guido, and A. Douglas Melamed, "Property Rules, Liability Rules, and Inalienability: One View of the Cathedral," Harvard Law Review, 85, No. 6 (April 1972), pp. 1089-1128.

48. The theory and practical application of property value studies is reviewed in: *The Benefits of Environmental Improvement*, supra note 20.

49. For the rest of this section, the term off-site will be used to refer to facilities owned and operated independently of a generator.

50. The issue of noncompliance in hazardous waste regulation is studied in: Ed Yand and Roger Dower, "Compliance vs. Noncompliance: The Case of Hazardous Waste Disposal," Forthcoming in *Environmental Professionals*.

51. This enforcement probability was chosen for illustrative purposes only.

Section VI

52. U.S. Environmental Protection Agency, *Siting of Hazardous Waste Management Facilities and Public Opposition*. Prepared by Centaur Associates, Office of Solid Waste Report SW-809. 1979.

53. *Ibid.*

54. See Michael O'Hare, "Improving the Use of Information in Environmental Decision Making," *Environmental Impact Assessment Review*, Vol. 1, No. 3, 1980.

55. For example, if given the choice of $1,000 with certainty or a 50-50 chance for $2,000, most people would opt for the former even though the expected value of the two choices is the same. They are risk adverse rather than risk neutral.

56. Supra, note 3.

57. *See Hazardous Waste Management: A Survey of State Laws 1976-1979*, Prepared by National Conference of State Legislatures, Washington, D.C., 1980.

58. Public Acts of 1979, State of Michigan, H.B. 4380, "Hazardous Waste Management Act," enacted 7/25/79 (see also *Hazardous Waste Report*, Vol. 1, No. 21, "Hazardous Waste Siting Boards," pp. 21-24, 1980).

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APPENDIX A

CASE STUDIES OF REGULATORY ANALYSIS

COKE OVEN CASE STUDY

Introduction

On October 22, 1976, the Occupational Safety and Health Administration (OSHA), an agency of the Department of Labor, promulgated a standard regulating worker exposure to coke oven emissions. Under Sections 6(b) and 8(c) of the Occupational Safety and Health Act of 1970 (OSH Act), OSHA lowered the then current permissible exposure limit to coke oven emissions and, in addition, specified certain engineering and work practice controls designed to allow coke oven plants to meet the performance standard.

Coke is formed by subjecting metallurgical coal to extremely high temperatures in one of two different, but similarly designed, ovens. Several ovens make up a battery, and any given coke plant will have several batteries. Simply put, coal is placed or "charged" into the top of the oven and heated. After a specified period of time the carbonized coal or coke is "pushed" out the end of the oven. Most coke produced in the United States is used as an input in the production of blast furnace pig iron which then becomes an input in the production of steel.

During the process of carbonization a complex mixture of gases is emitted in the oven. Since these gases have useful by-product properties, most ovens are equipped with devices to capture the emissions for further processing. There are several points, though, in the process where the emissions escape or are released into the general work environment. Based on a long history of medical research, these emissions are known to represent a serious health hazard and have been associated with increased risk of cancer among workers exposed to the emissions. The highest risk workers are those employed on the topside of the ovens where gases escape as the oven doors are opened during the charging process.

The statutory directive controlling the setting of permanent standards for occupational exposure to toxins, such as that for coke oven emission, is Section 655(b)(5) of the OSH Act. It provides in relevant part:

> The Secretary...shall set the standard which most adequately assures, to the extent feasible, on the basis of the best available evidence, that no employee will suffer material impairment of health or functional capacity even if such employee has regular exposure to the hazard dealt with by such standard for the period of his working life.... In addition to the attainment of the highest degree of health and safety protection for the employee, other considerations shall be the latest available scientific data in the field, [and] the feasibility of the standards....[1]

Though the paramount concern is worker safety, the "feasibility" qualification established a limitation on the stringency of standard. The guidance which this provision offers OSHA in standard setting is far from complete as a number of important considerations are left unaddressed, including the manner of defining "feasibility" and the manner in which the Secretary is to deal with scientific uncertainty. Also, the statute fails to offer concrete direction on the crucial issue of how the competing concerns of worker safety and the economic or technological difficulties accompanying stringent standards are to be balanced. As described in the following sections of this report, the case law had elucidated several aspects of these issues at the time that the coke oven standard was under consideration.

As mentioned above, the Act allows OSHA considerable flexibility in choosing the standards it will promulgate. Although it is difficult to form a complete picture of the OSHA regulatory decision process, interviews with Agency officials have provided some general observations on OSHA's priorities in setting and enforcing workplace safety and health standards.

The intention of the OSH Act was that standards be developed through an organized process. The Act formed the National Institute of Occupational Safety and Health (NIOSH) as the research arm of OSHA. One of NIOSH's responsibilities is the preparation of criteria documents, which act as the scientific underpinnings of new standards. NIOSH's priority setting process for the preparation of criteria documents depends on such factors as the extent of exposure, the toxicity of the substance, whether the exposures are likely to rise or fall in the future based on demand for final outputs, and so forth.

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Although OSHA can request NIOSH to prepare such documents, it tends to act independently of NIOSH and does not necessarily use the criteria documents in setting regulatory priorities. Several OSHA officials suggested that in the past the criteria documents have been weak from the viewpoint of cost estimates, technological feasibility assessments, and even the scientific evidence.

Upon its creation, OSHA adopted several thousand industry developed health and safety standards as National Consensus Standards. The priorities for setting new health standards at OSHA appears to be dictated by three factors: political pressure (primarily from unions), availability of sound scientific data on a particular hazard, and internal OSHA priorities. The latter are dependent on personal interests of the OSHA leadership as well as informal assessments of the magnitude of the various hazards. All of these factors are highly dependent on one another making it nearly impossible to separate out the influence of one over another in any particular case.

In addition to these three general factors, several more specific considerations enter the decision process as to whether to proceed with the rule-making procedures. The expected ease of enforcement is important and availability of OSHA enforcement personnel and the machanisms for monitoring and enforcement are reviewed. Once a standard has been issued, the degree of enforcement appears to be a function of (1) the level of possible health effects (i.e., are fatalities involved); (2) union pressure; (3) industry acceptance of the standard; and (4) employee complaints received.

The health hazards of coke oven emissions were formally recognized by industry at least as far back as 1967 when the American Conference of Governmental Industrial Hygienists set a threshold limit value to coke oven emissions. In 1971, the Department of Labor adopted the 1967 threshold limit value as the National consensus standard for exposure to coal tar pitch volatile (CTPV), which includes most of the organic components which are released from coal when it is heated. This standard was not specific to coke ovens, but was applicable to any source of CTPV which occurred in the workplace.

The American Iron and Steel Institute (AISI) petitioned OSHA, in 1971, to relax the existing standard as it applied to coke ovens. A second petition was filed a month later by the International Union of the United Steelworkers of American (USWA) which requested OSHA to promulgate a more stringent standard for exposure to CTPV around coke ovens. OSHA denied both petitions pending further study.

The decision to review the then current coke oven emission standard, although formerly prompted by the Union and industry petitions, was affected by a feeling among OSHA decision makers that because many coke oven plants are owned and operated by large steel firms, the industry was felt to be financially sound enough to bear the cost of a more stringent standard, if one was required. Nonetheless, it is clear that the two primary pressures that induced OSHA to undertake its review of the standard were the union request, and an extensive body of medical evidence detailing the adverse health effects of coke oven emissions.

Once the decision to review had been made, OSHA requested NIOSH to develop a criteria document examining worker exposure to coke oven emissions and submit proposals for regulation, if necessary. NIOSH proposed the use of various technical and work practice controls combined with the use of respirators to meet the existing standard, but did not recommend a change in the level of the standard. Following the NIOSH report, the Assistant Secretary of Labor for OSHA established an advisory committee. The committee, consisted of nine members: three industry representatives, scientists, and union representatives. The establishment of an advisory committee is standard procedure when reviewing a situation for regulation.

The advisory committee submitted a majority and minority report to OSHA. In the majority report, representing the findings of the union and science representatives, the committee proposed that emissions from coke plants be reduced to a zero exposure level, taking into account natural background levels. This would be more stringent than the existing standard. In addition, a number of technical and work practice controls were suggested. The minority or industry report called for either a less stringent performance or a technical specification standard.

In 1975, OSHA published a proposed standard for coke oven emissions. While the proposed standard was essentially the same as the majority committee's report, the indicator substance was changed from Benzo(a)pyrene [B(a)P] to respirable particulate matter (RPM), which was correlated with the suggested B(a)P level.[2] The actual level still remained at the zero exposure level. Following the release of the proposed standard, hearings were held and additional information was supplied by industry, unions and other interested parties.

An Environmental Impact Statement (EIS) and an Inflationary Impact Statement (IIS) were prepared and submitted by OSHA. Throughout the comment period on the proposed standard, industry, unions and scientists debated the issues of: what level of exposure should be permitted; what the indicator substance should be; whether to have a performance standard and/or a specification standard; what control technologies and

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work practice controls should be required; and if the estimated cost of the various controls justified their use. In making a decision in each of these areas OSHA had to deal with informational uncertainties, limitations in the scientific evidence and analysis, and disputes over the conclusions which would be reached from the available evidence. Each of these controversies will be discussed in more detail in later sections.

On October 22, 1976, OSHA promulgated the final standard regulating worker exposure to coke oven emissions. OSHA set a permissble exposure limit of 150 ug/m^3 of the benzene soluble fraction of total particulate matter averaged over an 8-hour period and, in addition, specified certain engineering and work practice controls designed to allow coke oven plants to meet the performance standard. This standard was more stringent than the original, but less stringent than the proposed standard.

Benefits of Regulatory Action--Health Risks

Occupational cancers resulting from the byproducts of coal combustion were first noted in 1755 and have been the subject of a long history of medical research since that time. Epidemiological, animal and chemical studies have linked coke oven emissions exposures with an increased incidence of skin, scrotal and respiratory tract cancer. In addition, these emissions have been shown to increase the risk of nonmalignant respiratory disease such as bronchitis and emphysema.

In promulgating the coke oven emission standard, OSHA relied primarily on a series of epidemiological studies, Redmond *et al.*,[3] to demonstrate the adverse health effects of the emissions. One study found that those workers with five or more years fulltime topside experience on coke ovens have ten times the lung cancer mortality rate of other steelworkers.[4] In a later study, Redmond, Ciocco, Lloyd and Rush reported that topside workers, partial topside workers and sideoven workers have 7, 2 and between 1.5 and 2 times the expected risk of developing lung cancer, respectively.[5] Updated studies support the conclusion of excess lung cancer mortality for coke oven workers.[6]

The epidemiological studies conducted by Lloyd and Redmond were part of a University of Pittsburgh study begun in 1962 which examined the occupational health hazards associated with the steel industry. The first study, published by Lloyd in 1971, compared the cause of death (mortality experience) of coke oven workers in 7 Allegheny County coke plants and non-coke oven workers with expected deaths by age, race, etc. for the total population. Two groups were studied with sample sizes of 1,327 or 2,048, depending on whether coke oven workers who worked in the plant before 1953 but were thereafter employed elsewhere were included in the sample. In addition to the results discussed above, coke oven workers were found to experience a mortality rate from respiratory cancer of 2.5 times that which is expected.

The Redmond _et al_. study provided support for these findings by comparing the Lloyd results for 2 of the 7 coke plants with lung cancer mortality rates in 10 plants outside Allegheny County. There were a total of 4,661 workers in both groups including workers in the outside Allegheny County plants employed from 1951-1955 and a non-coke oven control group which was examined through 1966. Again the results showed an excess risk of lung cancer mortality for coke oven workers. At the time of the hearings on the proposed standard, the Allegheny County findings had been updated through 1970. These results buttressed the earlier studies.

The results of these studies and the conclusion that coke oven emissions are carcinogenic were not questioned during the OSHA rule-making process of a coke oven emission standard.[7] Controversy did, however, arise in the interpretation of the findings and how they should affect the exposure limit to be set for the industry.

The difference in the interpretation of the conclusions for the medical studies resulted primarily from the use of different theories concerning the calculation of a dose-response relationship. One theory states that a single exposure to a carcinogen has the potential to cause cancer. Under this theory, the safe level of exposure is the maximum dose a person can be exposed to at one time and still not get cancer. This theory does not take into account repeated low-level exposure. The second theory assumes that repeated exposures have a cumulative effect. Therefore, a low dose which is experienced several times, or daily in the case of workers, can cause cancer, although each exposure by itself may not. The second theory generally results in a lower safe level of exposure.[8]

OSHA and the steelworkers union concluded from the Redmond studies that there was no safe level of exposure[9] to coke oven emissions and set the proposed standard at 300 ug/m^3 of respirable particulate matter (RPM), basically a zero exposure level if ambient background levels are taken into account.[10] This was an extremely stringent standard. The steel industry claimed that it could not be met feasibly, arguing that if the background levels in a particular region were higher than the standard permitted, it would be impossible to meet the permissible exposure limit. Industry held that the Redmond study indicated a safe exposure level of

560 ug/m^3 [11] of the benzene soluable fraction of total particulate matter (BSFTPM), which would be less stringent than the OSHA levels. This level was derived from a Redmond study conclusion that 200 ug/m^3 months of exposure of BSFTPM would not result in excess risk of cancer (0.560 ug/m^3 is the exposure level calculated in the study which over a 30-year time period would result in accumulation of 200,000-ug/m^3 exposure months or 200,000 ug/m^3 divided by 360 months or 30 years).

The Redmond study finally concluded that a 200-ug/m^3 exposure level would probably be necessary to provide adequate protection when coke oven workers with more than 30 years of experience are taken into account. Furthermore, during the course of the rule-making hearings Redmond testified that if several additional factors were considered, the study's epidemiological data would support a finding of a much lower safe exposure level, perhaps a zero safe exposure level. These factors included (a) the use of an extrapolation model more in conformance with currently accepted cancer theories than the one used in her study;[12] (b) the comparison of excess cancer rates in coke oven workers to U.S. population cancer rates as a whole and not just other steel workers; and (c) the use of an alternative, and available, data set showing lower levels of exposure.

Facing the uncertainties over the interpretation of the available data and appropriate methodologies for determining a "safe" exposure level, OSHA, in following its legislative mandate, held firm to its decision to err on the side of worker health and adopt a conservative posture. The agency argued that the safe exposure level must account for repeated exposures to coke oven emissions, therefore finding no safe level of exposure. Having made this determination, it remained for OSHA to decide what standard limit would constitute a feasible level.

During the public hearings on the proposed standard it became obvious to OSHA that the 300 ug/m^3 RPM and 0.2 ug/m^3 B(a)P permissible exposure level could not be met by the coke oven industry.[13] In response to these concerns, OSHA adjusted the standard upwards to 150 ug/m^3 BSFTPM. Two factors influenced this decision: economic and technological feasibility. The issue of technological feasibility is discussed below. The issue of economic feasibility is treated under economic costs.

Technological Feasibility--

Much of the evidence of technological feasibility came from an analysis of a U.S. Steel coke oven plant in Fairfield, Alabama. This plant had been rehabilitated and had the lowest emission levels of any battery in the country.[14] Studies of the emission levels at this plant showed that for one out of three days for which there was testing, the emission levels were equal to or below the new permissible exposure limit being considered by OSHA for each of seven job categories. This was taken by OSHA as a demonstration of feasibility. Drawing from the Advisory Committee[15] suggestions of possible engineering controls, controls in place at the Fairfield plant, and industry documents on suggested control technologies, OSHA determined both engineering and work practice controls that would enable industry to meet the standard and required these as part of the standard. If industry could not meet the permissible exposure level with these controls, respirators would be required as a backstop technology.[16]

Whereas there was little controversy on whether the suggested controls could reduce emission levels, there were at least two major questions concerning the ability of the known control techniques to reach the permissible exposure level. First, it was generally felt that the methods of compliance suggested in the proposed standard were overly specific.[17] The characteristics of each plant with regard to geographic location and other factors would affect the ability of any one plant to achieve the exposure level. Industry felt that more flexibility should be allowed and the feasibility of various controls should be evaluated. Second, the Fairfield plant was in compliance only one-third of its operating time. It was argued that if the cleanest plant in the industry could not meet the required standard all the time, how could OSHA expect the other plants to comply.

In the final standard, OSHA responded to the concern over technological feasibility by: (1) deleting some of the suggested controls that industry claimed would be be technologically or cost effective, while requiring the remaining control and work practice portions of the standard; and (2) arguing that the Fairfield plant had not yet implemented all of the required methods in the final standard, and that if they were to do so the standard could probably be met. In the event that the permissible exposure limit was still unattainable, OSHA claimed that there was evidence of new technologies being developed that could be used to meet the standard. Furthermore, OSHA required the coke oven industry to undertake research to identify other possible control techniques. It is noteworthy, though, that when questioned on the issue of deciding that a feasible level was one that was being met only one-third of time, an OSHA official did comment that while they realized the somewhat arbitrary nature of the choice, the dispersion of the best results from the Fairfield Plant seemed to indicate that this level was feasible. Finally, OSHA realized that variances under the OSH Act would allow them to tailor technical requirements to the specific needs of any particular plant.

The issue of technological feasibility had an additional, indirect effect on the OSHA rule-making process for coke ovens. Early on in that process, OSHA felt that it did not have enough information on the technical aspects of the problem. This situation was compounded by the fact that OSHA did not have a person on their staff who could adequately assess the relevant technical information. In order to remedy this deficiency, according to an agency official, OSHA proposed a standard calling for a zero exposure level, even though OSHA realized that this standard could not possibly be met. OSHA did this because it felt that a strict standard would prompt industry to supply more technical information. The additional information would facilitate the determination of a feasible emission level.

Even then, one former OSHA official has remarked that OSHA lacked the expertise to adequately evaluate the engineering and technical information supplied to them by industry. OSHA had to rely on industry assessments of the technical feasibility of the proposed controls throughout the decision process.

Conclusion--

OSHA did not formally quantify the benefits of the coke oven emission standards in terms of lives saved or value per life saved. Although the information with which to calculate benefits was available to OSHA, the agency stated that, "it is not appropriate to quantify even a range of the benefits of the final rule." Some estimates were provided, though, by other groups. For example, the Inflationary Impact Statement (IIS) calculated the range of lives saved by the proposed standard at between 26.6 and 240 per year. This estimate was challenged by both OSHA and the Council on Wage and Price Stability (CWPS). CWPS argued that the IIS has exaggerated the population at risk, among other things, and estimated that between 8 and 35 lives per year would be saved.[18] OSHA, on the other hand, using the CWPS technique, but a different estimate of excess mortality, calculated that 109 deaths per year would be averted.

The wide range of benefit estimates from the coke oven standard is due to the uncertainty surrounding two key variables: (1) the appropriate excess risk figure; and (2) the exposed population at risk. Furthermore, these estimates refer only to the benefits of reduced mortality from lung cancer and do not include estimates of reduced mortality from other cancers (prostate, pancreas, or large intestine), or reduced morbidity. Nor do they include estimates of those health risks averted for coke oven construction and repair workers, coal gas workers, and exposed neighboring populations. There were and are major difficulties in obtaining data on these types of health risks since the major scientific studies have been limited to lung cancer for coke oven workers.

In light of these uncertainties, OSHA merely stated that they expected reduced exposures to result in significantly reduced mortality rates. Although by this position it was not necessary to carry the discussion any further, OSHA went to some length to describe various methodologies for valuing life and then dismissing them with the statement, "OSHA believes that these methodologies do not adequately quantify the value of life. Accordingly, we decline to do so."[19]

Cost of Regulatory Action

After having chosen a proposed exposure level, OSHA was required by the OSH Act to show that the standard was economically feasible (the role of technological feasibility in the standard setting process has already been discussed.)

Economic Feasibility--

The issue of how great a financial strain a standard could place on the regulated employer and still be considered "feasible" was addressed in Industrial Union Department, AFL-CIO v. Hodgson.[20] The court concluded that a standard (in this case OSHA's asbestos standard) could be a great economic burden, even putting some employers out of business, and still be feasible.

> [S]tandards may be economically feasible even though, from standpoint of employers, they are financially burdensome and affect profit margins adversely, nor does concept of economic feasibility necessarily guarantee continued existence of individual employers.[21]

While small scale industrial closing may be considered acceptable, "massive dislocation" would be very suspect.[22]

> ...Congress does not appear to have intended to protect employees by putting their employers out of business--either by requiring protective devices unavailable under existing technology or by making financial viability generally impossible.
>
> Although Congress contemplated that Secretary's rulemaking pursuant to this section would put out of business some businesses so marginally efficient or productive as to be unable to follow standards otherwise universally feasible, court would not impute to congressional silence a direction to the

> Secretary to disregard the possibility of massive economic dislocation caused by an unreasonable standard.[23]

With this rather vague statutory and case law directive, OSHA contracted with D.B. Associates (DBA) to conduct a cost/economic impact analysis of the proposed standard. The economic analysis was subcontracted to Avril V. Adams and Associates.

Cost Estimates--

DBA estimated the costs of compliance through an informal survey of 12 coke producers, representing three-fourths of the coke production in the United States. Capital and annual operating and maintenance expenditures were estimated for paragraphs D-M[24] in the proposed standard and for the engineering controls and other items listed in the Appendix B[25] of the proposal.[26] In any one cost category three or four firms may have provided cost estimates. Where costs could not be obtained through interviews, other sources, such as trade journals, or best guesses were used. There costs were then extrapolated to all coke producers.

Two major adjustments were made to the data before the final cost figures were calculated. (1) the costs were adjusted downward by an amount representing the degree of compliance already in place or committed to under other state or federal programs. No adjustment was made for the "costs associated with items that might have been used to achieve compliance with the existing standard but were not used."[27] (2) A comparison of DBA's cost estimates with industry-provided costs reveals that the data may have been adjusted for possible overestimates by industry,[28] but without the raw data on which the DBA estimates were based, it is difficult to ascertain if such modifications were actually made.

By totaling annual capital costs (total capital costs were annualized using a .15 capital recovery factor) and annual operating and maintenance expenditures, DBA calculated total annual costs attributable to the coke oven standard. The low estimate, based on costs of complying with paragraphs D-M of the proposed standard, was $240 million per year and the high estimate, including costs of Appendix B items, was $1.28 billion. DBA stated that these are minimum costs of compliance and do not consider possible shortages, bottlenecks, etc.

Ideally, one would like to calculate costs of compliance at each plant in the industry and sum these costs to arrive at the total cost of compliance; rarely is this a practical procedure. Given the time and budget constraints on the contractors, the approach used by DBA seems to have been justified.

This conclusion is buttressed by the relatively minor interest of the industry or unions in the costing model technique. A careful review of the economic analysis does, though, suggest several problems or questions with the cost data or cost estimates that may have introduced some uncertainty.

(1) DBA analyzed and additional set of cost figures from a set of nine coke companies and compared these costs to their cost estimates derived from the original twelve firms. The large discrepancies between the two sets of estimates are attributed by DBA to: (a) a failure by the firm to use a standard method of costing; (b) different interpretations of standard requirements; (c) lack of differentiation between costs necessitated by other pollution control regulations; and (d) inclusion by some companies of the cost of lost coke production.[29]

While all of the above points have some merit, there are other reasons for the wide variation between company estimated costs and DBA estimates that are inherent in the costing technique used. In general, these include regional differences between plants, different plant sizes (OSHA admits that it may cost smaller plants more to comply than larger plants), differences in types of technologies used, and age differences between plants. Because it would be impossible to account for all the factors affecting the costs of compliance across the industry, and one cost estimate must be accepted with a certain degree of caution. DBA acknowledged this problem and cautioned that no technical statistical confidence could be attached to the cost estimates.

(2) Industry comments centered less on the different cost values used by DBA and more on which costs should be included in the final total cost figures. The major issue involved was whether cost of lost coke production due to the increased down time projected for oven repair maintenance should be included. Such costs, based on the cost of acquiring more expensive coke in the import market, were estimated for one firm to be around $100 million.[30] DBA and OSHA "did not consider these costs to be realistic."[31]

If such costs are a relevant factor, industry claimed that a higher cost estimate than the $240 million should be used by OSHA.[32] This entire argument represents an area of uncertainty. U.S. steel companies often import coke to supplement domestic supplies. The amount of coke imported varies from year to year and tends to increase during periods of near capacity utilization of blast furnaces. It is difficult to gauge the extent to which the OSHA standard will increase these demands.

(3) The United Steelworkers of America (USWA) argued that some of the specific cost estimates used by DBA extremely overestimated the actual costs that would be incurred.[33] They suggested major modifications in several of the capital cost categories (such as correcting for overestimates of cash requirements for hygiene facilities, ovendoors, and double drafting) and the capital cost calculations. Inclusion of these suggestions would have reduced the DBA capital cost estimates by more than 50 percent.

Without attempting to evaluate which cost estimates are more appropriate, the union comments bring up a more general problem involving the industry-provided cost estimates. There is reason to believe that industry may have an incentive to overestimate the costs of compliance.[34] Furthermore, if some firms stand to gain a competitive edge because of the regulation, they may have an incentive to underestimate the costs. For example, Inland Steel was the only company showing an increase in expected earnings per share as a result of the standard and their cost estimates were substantially lower than estimates for other firms.[35] Again, this suggests that the cost estimates should have been treated carefully.

Table A-1 shows the wide range of costs estimates for the proposed standard that were calculated by various groups.[36]

TABLE A-1.
COST COMPLIANCE ESTIMATES FOR PROPOSED REGULATION
(in millions of dollars)

Source of estimate	Total capital costs	Annual capital cost	Other annual costs	Total annual cost
DBA I-1	451	68	173	241
DBA I-2	451	45	173	218
DBA II	860	130	1,150	1,280
CWPS LL-1	410	62	98	160
CWPA LL-2	410	41	98	139
Steelworkers (e)	200	30	173	203

Economic Impacts--

Using the cost data estimated by DBA, the potential economic impacts of the proposed standard were calculated. The analysis included consideration of employment, productivity, costs of production, market structure, competition, inflation and financial impacts. In assessing the ecomomic feasibility of the standard, the most important class of impacts are those that relate to the ability of the industry to meet the costs of compliance. The IIS recognized the difficulty coke producing firms might find in borrowing capital to meet the coke oven standard's requirements and that the actual financial impact would be a function of the size of the firm (the IIS stated that it would be harder for smaller firms to raise the required capital); the length of time over which the costs are financed; the adequacy of internal capital generation; and the costs of compliance. [The IIS stated that, "While such figures (annual operating and maintenance costs as a percent of an eight year average of after tax profits) are substantial, particularly since the OSHA coke over regulations represent only a fraction of the ultimate impact of possible OSHA standards, the more severe impact is caused by the capital requirements of the proposed standard."][37] Because of the variability in the performance of the overall economy and factors listed above, the financial impact of the standard is highly uncertain. The IIS though did admit that "... a potentially serious financing problem faces the steel industry during the next decade. The capital costs of the proposed OSHA coke oven regulations may exacerbate this financing problem."[38]

Conclusion--

OSHA acknowledged most of the uncertainties noted above, but did not modify the DBA cost estimates in light of the comments. They declined to accept any one estimate, stating that,

> ...OSHA has concluded it would be inappropriate to accept any one of these estimates as its own or to make a definitive estimate of the actual costs necessary to comply with the proposed standard...[39]

Instead they stated that costs of the final regulation would be in the $200 million range. They also admitted that the estimates of future costs of control (lost coke production) and possible research and development expenditures are too speculative to be estimated.[40] It in noteworthy that the OSHA cost range, depending on how broadly one defines a range, includes the lower of the DBA cost estimates ($240 million) and the lower of the CWPA estimates ($160 million). The CWPS estimates were calculated by deflating the DBA estimates by the Inland Steel estimates to account for potential overstatement of costs. This suggests some distrust for the industry data on OSHA's part; a distrust acknowledged by one OSHA official.

OSHA did not address or resolve uncertainty over the financial impacts of the standard. Their legislative mandate was met as long as there were no mass closings of the firms in the industry. OSHA was content to defend financial feasibility by the fact that:

> ...none of the steel industry spokesman testified that the proposed standard for coke oven emissions would imperil the existence of the coke industry in the United States.[41]

Summary and Conclusion

From the beginning of OSHA's rule-making process on the coke oven emission standard, the agency was forced to address significant issues involving uncertainty. Two of the most important, scientific and technological uncertainties, have been highlighted in this case study. OSHA's treatment of uncertainty was guided principally by its legislative authority and case law.

Scientific Uncertainty--

The highly protective tenor of Section 655(b) which seeks "the attainment of the highest degree of health and safety protection" suggests an intent to resolve scientific uncertainties in a manner which provides more complete worker protection. This is evident in the legislative history. The House report states: "It is not intended that [OSHA] be paralyzed by debate surrounding diverse medical opinions."[42]

The case law has in general followed this construction. In Society of Plastic Industry, Inc. v. OSHA, challenging the regulation of occupational exposure to vinyl chloride, the court stated:

> ...[T]he ultimate facts here in dispute are "on the frontiers of scientific knowledge," and, though the factual finger points, it does not conclude. Under the command of OSHA, it remains the duty of the Secretary to act to protect the working man, and to act even in circumstances where existing methodology or research is deficient ...[43]

Courts have been consistent in regarding the resolution of scientific uncertainty as not simply a factual determination, but also a policy judgement.

> Some of the questions involved in the promulgation of these standards are on the frontiers of scientific knowledge, and consequently as to them insufficient data is presently available to make a fully informed factual determination. Decision making must in that circumstance depend to a greater extent upon policy judgements and less upon purely factual analysis.[44]

This approach engenders greater deference in judicial review of OSHA's resolution of issues on the "the frontiers of science." Instead of the more stringent "substantial evidence" test traditionally applied to administrative factual determinations, review focuses on rationality and general conformance with the legislative mandate.

> Regardless of the manner in which the task of judicial review is articulated, policy choices of this sort are not susceptible to the same type of verification or refutation by reference to the record as are some factual questions ...[45]
>
> ...The paramount objective is to see whether the agency, given an essentially legislative task to perform, has carried out in a manner calculated to negate the dangers of arbitrariness and irrationality in the formulation of rules for general application in the future.[46]

This position was further articulated in the Third Circuit's review of the coke oven emissions standard, a challenge brought by a variety of steel and coke manufacturers.[47] Here, the court upheld the exposure limitation finding that OSHA's factual determination on the carcinogenic effects of coke oven emission was supported by substantial evidence.

> The Secretary's factual determination that coke oven emissions are carcinogenic and that there is no absolutely safe level of exposure to them is supported by substantial evidence in the record. Therefore, we have no difficulty in concluding that the Secretary's effort to meet a perceived health need by establishing an exposure limit to coke oven emissions was proper.[48]

Technological Feasibility--

The considerations governing the extent to which OSHA can set standards requiring the use of presently unavailable technology closely parallels those discussed earlier in reference to economic costs and impacts. Generally stated, small-scale dislocation may be allowable, whereas widespread industrial dislocation would meet very careful judicial scrutiny and almost surely result in a decision that the standard was not "feasible."[49]

Clearly, at least some degree of technology forcing is permitted. In Society of Plastics, OSHA had established a permissible exposure level of one part per million (ppm) of vinyl choride over an eight hour period. Even though no plant had been able to reach this level at the time of adjudication, Justice Clark, sitting by designation, upheld the standard.

> We cannot agree with petitioners that the standard is so clearly impossible of attainment. It appears that they simply need more faith in their own technological potentialities, since the record reveals that, despite similar predictions of impossibility regarding the emergency 50 ppm standard, vast improvements were made in a matter of weeks, and a variety of useful engineering and work practice controls have yet to be instituted.[50]

As has already been described, OSHA went through a detailed analysis of the feasibility of alternative technologies for the control of coke oven emissions. This began with a review of the existing information from which were drawn the control techniques suggested in the proposed standard and continued with a re-evaluation of those controls due to industry comments. The final regulation acknowledged some of the problems with the control technologies suggested in the proposed standard and omitted those that the Agency felt were not practicable. The remaining controls were required. Clearly, the Agency did address technical feasibility as the statute required. OSHA also took advantage of the technology forcing interpretation of the OSH Act, by requiring firms to implement new technologies that may become available in the future.[51]

The Agency's approach to technological uncertainty was only modified, though, in the Third Circuit's decision. While the court held that OSHA could require the development and use of technologies "looming on the horizon," it also stated that the agency did not have authority to require "openended" technological development.

Balancing Costs and Benefits--

OSHA did not undertake a formal cost/benefit analysis of the coke oven emission standard, nor did the agency attempt to compare the costs of the regulation wth the expected benefits in a less structured manner (i.e., dollars spent per cancer death avoided). Again, the agency's legislative mandate, as interpreted by OSHA, provided the guiding justification. To assure adequate protection of worker health, the agency need only consider whether industry is capable of meeting the standard (in a technical or economic sense). Benefits need not be compared to costs.

The issue of OSHA having to balance costs and benefits in setting health standards, though, is by no means clear cut, and is yet to be finally settled. In a parallel case involving OSHA's benzene exposure standard, the Fifth Circut in remanding the standard back to the agency held that the benefits from the standard must bear a "reasonable relationship" to the costs. The court was somewhat ambiguous, though, in outlining in practical terms exactly what type of analysis is necessitated by this requirement.

> Although the agency does not have to conduct an elaborate cost-benefit analysis,... it does have to determine whether the benefits expected from the standard bear a reasonable relationship to the costs imposed by the standard.
>
> The only way to tell whether the relationship between the benefits and costs of the benzene standard is reasonable is to estimate the extent of the expected benefits and costs.[52]

The cost/benefit question was not given a further clarification in the recent Supreme Court Review of the benzene standard in which they upheld the Fifth Circuit's decision.[53] Whether OSHA can continue to disregard cost/benefit comparisons remains to be seen.

CWPS, during the course of the public hearing on the coke oven standard, did attempt to calculate the implicit value of lives saved in the proposed standard. By comparing alternative cost estimates to benefit estimates from lung cancer deaths averted, CWPS estimated a range of implied value of human life of between $4.5 million and $158 million. Furthermore, they cited that these estimates, albeit uncertain and relating only to lung cancer deaths (a benefit estimate including morbidity effects was calculated at $2.25 million by dividing the lowest estimate by 2), were many times larger than value of life estimates used by other agencies, CWPS argued that less costly ways of achieving the standard should be considered.

There are several substantially different methods which could reduce worker exposure to coke oven emissions. (1) The amount of gases which escape from the ovens could be reduced through the use of technical controls on the ovens. (2) Workers could be required to wear safety equipment such as respirators. (3) Workers' total exposure could be reduced by rotating workers off the coke ovens. (4) OSHA could simply require industry to reduce worker exposure to a specific level without specifying how to reach that level.

OSHA did not formally examine these alternatives extensively. OSHA rejected the possiblity of relying on respirators because of the problems involved with getting workers to wear them all the time, since they are uncomfortable and prohibit communication. OSHA did require them as a back up measure until the emissions levels are met. Worker rotation was also rejected by OSHA as unreasonable since it would expose many more workers to the hazard.

Footnotes

1. 29 U.S.C. §655(b)(5) (1970). For an insightful analysis of this provision *see* Doniger, *Federal Regulation of Vinyl Chloride: A Short Course in the Law and Policy of Toxic Substances Control*. 7 ELQ 497 (1978).

2. As explained in a later section of the report, the numerous substances in coke oven emissions require, for regulatory purposes, that one substance be chosen as an indicator for measurement purposes.

3. Carol K. Redmond, J.W. Lloyd, A. Ciocco, H. Robinson, E.M. Smith, H.W. Rush, F.E. Lundin, Jr., P.B. Geiser, Long Term Mortality Study of Steelworkers," *Journal of Occupational Medicine*, June 1969, 11:6 pp. 299-310; August 1969, 11:8, pp. 411-416; October 1969, 11:10, pp. 514-521; May 1970, 12:5, pp. 151-157; February 1971, 13:2, pp. 53-68.

4. *Ibid.*

5. Report by American Iron and Steel Institute -- *Information and Data for Use in Preparation of National Institute for Occupational Safety and Health (NIOSH) Criteria Document*.

6. Office Research and Development, U.S. Environmental Protection Agency, *An Assessment of the Health Effects of Coke Oven Emissions* (Washington, D.C., 1978).

7. Occupational Safety and Health Administration, U.S. Department of labor, *Final Environmental Impact Statement: Coke Oven Emissions*, August 1976, p. 20. 41 Fed. Reg. 46746 (October 22, 1976).

8. For a description of various mathematical models for high dose to low dose extrapolations, see: Scientific Basis for Identification of Potential Carcinogens and Estimation of Risks, [44 Fed. Reg. 39858, (July 6, 1979)].

9. [41 Fed. Reg. 46755 (October 22, 1976)]. United Steelworkers of American, AFL-CIO, Post-hearing Brief of Standard of Coke oven Emissions, June 16, 1976, p. 60.

10. Throughout the rule making process for the coke oven emission standard, several different indicator substances were considered by the agency. Each of these substances measure a different aspect of the emission (for example, B(a)P is a specific component of coke oven emissions while BSFTP, contains all the organic components of the emission). It is important to note that the numerical values alone are not indicative of the stringency of the standard; the indicator substance must also be considered. The table below ranks the alternative standard levels considered by the agency in order to increasing stringency.

Most Stringent	300 ug/m^3 RPM based on .2 ug/m^3 B(a)P (zero exposure level)	Proposed Standard
	150 ug/m^3 BSFTPM	Final Standard
	200 ug/m^3 CTPV	Original Standard (1967)
	200 ug/m^3 BSFTPM	Redmond Study Value
Least Stringent	560 ug/m^3 BSFTPM	Industry Value

11. Although the common scientific notation used when defining these substances is mg/m^3 (milligrams per cubic meter), due to the small magnitude encountered in this case, the notation used in this text is ug/m^3 (micrograms per cubic meter) to make the numbers more manageable (1 mg = 1,000 ug).

12. For example, the relative risks of developing lung cancer at 200 ug/m^3 exposure level at latency periods of 0, 5, 10, and 15 years were calculated at 6.27%, 7.7%, 9.5%, and 13.1% greater than normal using one type of model and 41%, 45%, 52%, and 63% greater using an alternative model.

13. Coke oven emissions contain a variety of compounds, many of which have not yet been identified, and cancer causing

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aspects of the emissions are not well understood. It is therefore necessary to choose one component of the emissions as an indicator to define the permissible exposure level. During the rule-making, considerable controversy centered on the issue of which indicator substance should be used. In the proposed standard the Advisory Committee suggested that the indicator substances by B(a)P (a known carcinogen) and RPM which is a lung irritant and possible cocarcinogen. The industry wanted to use coal tar pitch volatiles (CTPV) which is essentially the same as BSFTPM. This substance contains all the organic matter in the coke oven emissions and therfore the cancer causing agents. OSHA chose in the proposed standard to use RPM as the indicator substance, and B(a)P as an additional measure, but changed to BSFTPM in the final standard. This decision was based on several considerations, the most important of which was that the available epidemological studies were conducted in terms of BSFTPM and that no such evidence was available for RPM or B(a)P. Furthermore, OSHA, as well as others, held that CPTV and BSFTPM were for all practical purposes the same substance. Other reasons for chosing BSFTPM include: easier and more accurate testing and its relatively specific nature.

14. National Institute for Occupation Safety and Health, Report on Survey of Fairfield Coke Batteries, Fairfield, Alabama (Washington, D.C., 1975) Table 1.

15. Report of the Standards Advisory Committee on Coke Oven Emissions (Washington, D.C., 1975) pp. 30-43.

16. National Institute for Occupational Safety and Health, Criteria for Recommended Standard...Occupational Exposure to Coke Oven Emissions (Washington, D.C., 1973).

17. Report of the Industry Members of the Standards Advisory Committee on Coke Oven Emissions to the Secretary of the Department of Labor (Washington, D.C., 1975) p. 21.

18. Council on Wage and and Price Stability, Testimony Before the Occupational Safety and Health Administration, U.S. Department of Labor, Informal Public Hearing on Proposed Coke Oven Emissions Standard (Washington, D.C., May 13, 1976) Transcript pp. 4688-4798, (CWPSTR).

19. 41 Fed. Reg. 46751 (October 22, 1976).

20. 499 F.2d 467 (D.C. Cir. 1974).

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21. 499 F.2d 467, 478 (1974) *see also* American Federation of Labor and Congress of Indus. Organizations v. Brennan, 530 F.2d 109 (3d Cir. 1975).

22. But mass closings would not necessarily be invalid in all cases. With a very dangerous risk and an unimportant industry such an action might be upheld. *See* above footnote.

23. (See note 19).

24. 40 Fed. Reg. 32273-32275 (July 31, 1975).

25. *Ibid*. p. 32281.

26. Paragraphs D-M outline the work practice, medical surveillance, and record keeping provisions of the standard. Appendix B contains the suggested control technologies.

27. IIS *supra*. p. 13.

28. CWPS *supra*. p. 3.

29. IIS *supra*. p. 25.

30. Bethleham Steel Corporation, Statement for the U.S. Department of Labor Public Hearings on the Inflationary Impact Statement of Occupational Exposure to Coke Oven Emissions (Washington, D.C., 1976) p. 4.

31. IIS *supra*. p. 25.

32. United States Steel Corporation, Position Concerning the Inflationary Impact Statement of the Proposed Coke Oven Emissions Standard (Washington, D.C., 1976) p. 4.

33. Union Statement on Capital Costs.

34. CWPS *supra*. p. 3.

35. *Ibid*. p. 3-4.

36. IIS, p. 89.

37. *Ibid*. p. 91.

38. 41 Fed. Reg. 46749 (October 22, 1976).

39. *Ibid*. p. 46749.

40. 41 Fed. Reg. 46748 (October 22, 1976).

41. *Ibid*. p. 46748.

42. H.R. Rep. No. 1291, 91st Cong., 2d Sess. 18 (1970).

43. 509 F.2d 1301, 1308 (1975); *see also* Industrial Union Dept., AFL-CIO v. Hodgson 499 F.2d 467 (1974) [hereinafter *Industrial Union*].

44. Industrial Union Dept., AFL-CIO v. Hodgson, 499 F. 2d 467, 475; Other circuits had adopted similar approaches at the time that the coke oven standard was under consideration. *See* Society of Plastics Indus., Inc. v. OSHA, 509 F.2d 1301 (2d Cir. 1975) (vinyl chloride standard); Synthetic Organic Chem. Mfrs. Ass'n v. Brennan, 506 F.2d 385 (3d Cir. 1974), *cert. denied* 423 U.S. 830 (1975), *reh. denied* 423 U.S. 866 (1975) (14 carcinogens).

45. Industrial Union at 475, *quoting with approval*, Automotive Parts & Accessories Ass'n v. Boyd, 132 U.S. App. D.C. 200, 407 F.2d 330, 338 (1968).

46. *Ibid*.

47. 509 F.2d 1301, 1309 (1975). When the coke oven standard was reviewed in the Third Circuit, the court took the opportunity to further define the limits of technology forcing. However, this decision was appealed to the Supreme Court and was granted certiorari (non-mandatory Supreme Court review). 577 F.2d 825 (1978). Before the Supreme Court could review the appeals court decision, though, the industry petitioners withdrew the case. The industry argued that they were already mainly in compliance with the standard. Because of the recent nature of this decision, September 1980, it is not possible to investigate whether this is true or not.

48. The more far reaching technology forcing provisions of the standard were subsequently found invalid in judicial review. *Ibid*., 577 F.2d 825 (1978).

49. American Petroleum Institute v. OSHA 581 F.2d 493 , 8 ELR 20790 (5th Cir. 1978).

50. 577 F.2d 825, 832.

51. *See e.g.*, American Federation of Labor and Congress of Indus. Organizations v. Brennan 530 F.2d 109 (3rd Cir. 1975).

52. 581 F.2d 493 (1978).

53. For discussion of the Supreme Court's Benzene decision in light of OSHA policy on worker health risks see: Scalia, A. "A note on the Benzene Case," Regulation, July/August 1980, pp. 25-28 and Doniger, D.D. "Occupational Health," The National Law Journal, Sept. 15, 1980, pp. 26-27.

AFLATOXIN CASE STUDY

Introduction

Aflatoxins are a group of highly toxic compounds produced by naturally occurring molds that are found on growing nuts and grains and multiply rapidly under poor storage conditions. In high doses, aflatoxin can cause acute effects, such as liver disease, and usually death. In lower doses, which are much more frequent, aflatoxins are a potent liver carcinogen in some laboratory animals and are thought to be a liver carcinogen in humans.

Aflatoxins were first identified in 1961 after an unknown disease caused an estimated loss of at least 100,000 turkey poults in England.[1] Death was due to serious liver damage, a condition now known as aflatoxicosis. Investigations showed that the common molds, *Aspergillus flavus* and *Aspergillus parasiticus*, found in the Brazilian groundnut meal (peanut meal commonly used for animal feed) metabolize the aflatoxins responsible for the deaths (henceforth, "*A. flavus*" will denote both *A flavus* and *A parasiticus*). Since that time aflatoxin has been found to contaminate several other commodities.

Government Policy

The first steps in the United States to reduce levels of aflatoxins in foods were taken in the early 1960s when the peanut industry, fearing that an aflatoxin scare could destroy the market for peanuts, asked the Department of Agriculture (USDA) to establish a quality control program.[2] USDA designed such a program in 1964, and continues to administer a voluntary peanut marketing agreement program through the Peanut Administrative Committee (PAC), an 18-member committee composed of peanut producers and shellers from each of the three producing regions. The program diverts peanuts with high aflatoxin content from being processed into human food.

Regulation of aflatoxin content in final peanut products began in 1965 when the FDA set an administrative guideline (action level) of 30 ppb. The authority for this action was the Federal Food, Drug and Cosmetic Act (FFDCA) §402(a)(2) which states that foods containing added poisons or added deleterious substances are considered adulterated and prohibited from entering interstate commerce. The 30 ppb limit was based on the level of aflatoxins which could at that time be consistently detected at a reasonable cost.[3] To further reduce aflatoxin exposure would either entail much higher inspection costs or a ban on peanut products, alternatives considered infeasible by FDA. In 1969, FDA determined that analytic techniques had improved enough that the action level could be lowered to 20 ppb.[4]

The current FDA proposal to further lower permissible aflatoxin levels in consumer peanut products involved two policy changes. First, FDA proposed to regulate aflatoxin under §406 instead of §402(a)(2) of the FFDCA. Under §406, FDA could issue a regulation setting permissible levels of aflatoxin as opposed to the more informal action levels permitted under §402(a)(2). If a case should go to court, under §402(a)(2) FDA must demonstrate that aflatoxin is an added poison or added deleterious substance; under §406 with a regulation FDA need only demonstrate that the aflatoxin level in the product exceeded the permitted amount. The problem with a regulation is that it is harder to change than an action level, and thus less flexible in adapting to technological change. Generally, FDA would propose to use tolerances when the technical procedures and information concerning the health risk are static; otherwise an action level is more appropriate.

The second proposed policy change was to lower the acceptable level of aflatoxin in peanuts and peanut products from 20 to 15 ppb. In determining the appropriate tolerance the Commissioner sought to balance four factors:

1. the need to minimize human exposure to aflatoxins;
2. the capabilities of sampling procedures and analytical methods to detect, measure and confirm the aflatoxin;
3. the capability of agricultural and manufacturing technology to prevent and remove contaminated peanuts; and
4. the need for the continued availability of peanuts as a low cost protein source.

The 15 ppb tolerance level was held to be feasible because 93 percent of the peanut butter and 97 percent of the other products sampled since 1969 already met that limit. The Commissioner considered setting the tolerance level at 5 or 10 ppb but felt that these levels would impose significant losses on producers, manufacturers and consumers since, according to a 1973 FDA survey, only 89% of peanut butter and 82% of other peanut products could meet a 10 ppb tolerance.

In addition, for producers to reach a 10 ppb tolerance, they would have to set inspection standards at 1-5 ppb in order to allow for the large sampling error. But, in this range, present sampling techniques have considerable error making adherence to the limit technically infeasible for the industry. FDA felt that the 15 ppb level was technically feasible for the industry to meet, and thus it was the superior option.[5] FDA has not finalized the 15 ppb tolerance level as of this writing (October 8, 1980) although it has continued to investigate aflatoxin.

In the interim, FDA has deliberated the problem with increasing sophistication. In January of 1978, FDA issued a risk assessment in which it quantified the benefit to public health from setting various tolerances for aflatoxin in peanut products. Based on the epidemiological studies, FDA extrapolated lifetime liver cancer rates resulting from ingestion of peanuts and peanut products to be an average of 1.1 per 100,000 with a 20 ppb action level. Based on the incidences expected at lower tolerances, FDA concluded that "relatively no significant gain" in the protection of public health would be obtained by tolerances lower than 15 ppb.[6] It reopened the comment period on the 15 ppb tolerance on March 3, 1978.[7]

The FDA has identified other crops susceptible to aflatoxin contamination and has established control programs. (See Table A-2) For other commodities, such as domestically produced sorghum, rye, wheat, rice, barley, oats, soybeans, figs and treenuts,* FDA has determined that they do not contain enough aflatoxin to warrant control measures. Imported filberts, Brazil nuts and pistachio nuts have had high aflatoxin levels, but the levels have been greatly reduced, with the implementation of import inspection programs.[8]

Other than peanuts, the commodities in which aflatoxin continues to pose a significant health problem are corn and cottonseed. Contamination in corn is largely confined to the southeast where per capita consumption of grits and cornmeal, two of the corn products in which aflatoxins are not eliminated during processing, is quite high.[9] Both corn and cottonseed are fed to food-producing animals and if contaminated, can leave residues in tissues. The ratio of contamination in the feed to tissue residue varies between animals and organs.[10] (See Table A-3) In all cases, the present control level of 20 ppb is far lower than the required to insure no detectable residues in tissues.[11] (Residues are either aflatoxin B_1, the most common and most potent of the group, or aflatoxin M_1, an animal metabolite of B_1 with 3% the potency of B_1). Milk is the most vulnerable animal product to aflatoxin contamination. FDA officials consider elimination of M_1 in milk of prime importance because milk can compose the entire diet of infants; infants appear to be more vulnerable to the effects of aflatoxins than adults. Thus, on December 6, 1977, FDA set an action level of 0.5 ppb M_1 in milk.[12]

TABLE A-2

APPROXIMATE INCIDENCE AND LEVEL OF AFLATOXIN CONTAMINATION ENCOUNTERED IN SUSCEPTIBLE COMMODITIES IN THE UNITED STATES

Commodity	Incidence (% or Ratio[a])	Total Aflatoxins Average[b] (ng/g)	High	Source of Data
Peanuts	35	33	100	c
Cottonseed (Far West)	41	215	1,500	d
Cottonseed (Southeast)	8	50	150	d
Corn (Southwest)	44	54	500	d,20,31
Corn (Midwest)	2.5	5	37	29,30,39
Sorghum	4/786	17	50	e
Rye	2/35	T	--	e
Wheat	1/1,528	11	--	e,34,35
Rice	1/182	5	--	e
Barley	0/234	--	--	e
Oats	0/416	--	--	e,35
Soybeans	2/866	11	11	e,35
Pecans	39/575	86	172	e
Walnuts	8/330	27	70	e
Almonds	36/557	27	90	e
Filberts	0/99	--	--	e
Figs	1/106	10	--	e

[a] Ratio of contaminated to total samples examined.

[b] Average of contaminated samples.

[c] Peanut Administrative Committee data.

[d] M. Whitten, ref. 42 unabridged data rcd. as personal communication.

[e] Food and Drug Administration, unpublished data.

From Stoloff, Leonard. "Incidence, Distribution and Disposition of Products Containing Aflatoxins."

TABLE A-3

MOST LIKELY RATIOS OF FEED LEVELS OF AFLATOXIN B_1 TO EDIBLE TISSUE LEVELS OF AFLATOXIN B_1 or M_1 [1]

Animal	Edible Tissue	Aflatoxin in Tissue	Feed/Tissue Ratio
Beef Cattle	liver	B_1	14,000
Dairy Cattle	milk	M_1	300
Swine	liver	B_1	800
Layers	eggs	B_1	2,200
Broilers	liver	B_1	1,200

Rodricks and Stoloff in Rodricks

FDA is limited in its regulation of aflatoxins in corn and cottonseed since most of the contaminated lots do not move interstate. Grits and cornmeal in the southeast are frequently locally consumed and produced. In the southwest, the region with the highest contamination levels, cottonseed, is used as animal feed primarily in the state in which it is produced. FDA can, and has, regulated the contaminated milk moving interstate, but intrastate regulation can only be achieved by the states. FDA has been working with states, encouraging them to develop aflatoxin extensions and experimental stations to educate farmers about the aflatoxin problem and its control.[13]

In the following discussion of FDA's treatment of costs and benefits in the regulatory decision process, attention is focused primarily on peanuts. Of the products susceptible to contamination only corn and cottonseed, in addition to peanuts, continue to develop high aflatoxin levels. As mentioned above, consumer products from these crops typically do not move in interstate commerce and cannot be regulated to FDA.

The Benefits of Reducing the Aflatoxin Guideline

The benefit of reducing aflatoxin levels in peanuts is the reduction in adverse health effects resulting from aflatoxin exposure. Ideally, before developing a regulation, a regulator would want to know what health problems result from current exposure levels, how much health is improved by a reduction in exposure. Much of this information for aflatoxin was not available when FDA began regulating peanuts in 1965. Since then a great deal has been learned, but the information is still incomplete.

In sufficiently high doses, aflatoxin may cause acute liver disease or aflatoxicosis, as seen in the turkey poults in 1961. Acute aflatoxicosis is rare among humans and no cases in the United States are known.[14] The few known cases were in Africa and India, and most involved children. In some cases, the adults eating the same aflatoxin-contaminated food as affected children experienced no acute effects, hence scientists speculate that children are more susceptible to aflatoxin than adults.

Lower doses are thought to cause two other diseases seen primarily in children. The first is childhood cirrhosis, a common cause of death among children in India but rarely seen in the United States.[15] The second disease is encephalopathy and fatty degeneration of the viscera (EFDV), another common disease among Indian children.[16] EFDV is thought to be the same as Reye's syndrome, the tenth most common cause of death among children in the United States.[17]

FDA officials have been most concerned that levels of aflatoxin below those inducing the acute reactions discussed above may cause liver cancer in humans. The evidence supporting this belief is contradictory and leaves crucial questions unanswered. Part of the evidence is provided by the results of animal tests and part is provided by the epidemiological studies. Each group of tests leaves questions about the carcinogenicity of aflatoxins to people in the United States. The evidence is discussed in more detail below.

In a body of literature too great to be discussed in detail, aflatoxin is conclusively shown to be a liver carcinogen in animals. Dozens of studies dating back to the early 1960s have investigated the relationship between aflatoxin and liver cancer and have almost uniformly found positive results. The strength of the findings is supported by the lack of controversy about the methodologies used in the experiments and by the number of species developing liver cancer from aflatoxin: rainbow trout, salmon, duck, Rhesus monkeys, mice tree shrews, sheep, rats and marmosets.[18]

Of all the test animals, rats have been most frequently studied, and are also one of the most sensitive to aflatoxin. Aflatoxin is the most potent liver carcinogen yet seen in rats. For this species, scientists have been able to identify a dose-response curve; that is, they have found the incidence of liver cancer to rise with the dose level of aflatoxin. In addition, it was found that the same total dose was more carcinogenic when administered over several days than all at once.[19]

Using the results of animal studies, particularly the results from rat studies, to predict the carcinogenic response in humans to aflatoxin presents several difficulties. The tests show different species to have different susceptibilities to aflatoxin. While rats are the most sensitive, humans appear to be among the more resistant species.

FDA used two groups of animal studies to extrapolate to the liver cancer incidence in humans. First, average and maximum aflatoxin exposures were estimated from surveys made of foods consumed in the region of highest contamination, the southeast. They found total exposure to average 0.1 ppb with an extreme upper range of 0.3 ppb of the diet. Of this exposure peanuts contributed an average 0.005 ppb and 0.013 at most. The remainder, by far the larger portion, was contributed by dry-milled corn products. One group of animal studies was composed of five rats studies representing the range of cancer incidences; the second group was composed of five studies on other animal species. Using the Mantel-Bryan model, FDA extrapolated the results to the same ppb of the diet as in the diet of an average person in the southeast, making no adjustment for differences in susceptibility between species. The results predicted a higher rate of liver cancer than observed from all causes in the United States, leading FDA officials to conclude that using the results of animal studies was not appropriate in calculating the risk of aflatoxins to humans.

Epidemiological studies make up the second type of evidence showing the incidence of liver cancer caused in humans from aflatoxin. The four major studies, conducted in Kenya, Swaziland, Mozambique and Thailand, show a strong correlation between liver cancer incidence and levels of aflatoxin.[21] The high correlation found in the four studies is supported by several factors. The same relationship was detected in populations with different exposures and eating habits. The results are relatively consistent in differentials in the age of highest frequency of occurrence and sex susceptibility, males being the more susceptible. Kenya, Swaziland and Thailand, regions with relatively high aflatoxin contamination, have greater incidence of liver cancer. In Swaziland, tribes that eat greater quantities of peanuts, the commodity carrying the most contamination, show a greater incidence of liver cancer than other tribes of the same region.[22]

While that data supports the contention that humans are more resistant to aflatoxin than rats, several difficulties in the studies indicated the results should be cautiously evaluated. As with all epidemiological studies the methods used to estimate both exposure to aflatoxin and the incidence of liver cancer had many limitations. In particular, these studies on aflatoxin suffer from not knowing what other liver carcinogens to which the population was exposed. Exposure was estimated by taking samples of only the meals, neglecting to measure the aflatoxin content of peanuts eaten as snacks. The studies measured current aflatoxin exposure and correlated it with current liver cancer incidence, although ideally one would want to know aflatoxin exposure 20 to 30 years before the observed present liver cancer rates to allow for the latency period of cancer. The incidence of liver cancer was also roughly estimated because these countries kept poor medical records.[23]

The United States data on liver cancer incidence raises further questions as to its carcinogenicity. The region with the highest levels of aflatoxin exposure has an incidence of liver cancer only equal to the national average, not greater as theory would lead one to predict. Furthermore, those citizens of Oriental descent have a far greater incidence of liver cancer than citizens of other backgrounds. This evidence led FDA officials to conclude that other agents may be more responsible for liver cancer in the United States, and that genetic differences may create large variances in susceptibility of different individuals to the disease.[24]

Since FDA felt the health risks predicted using results from animal tests were unrealistically high, it performed a second extrapolation based on epidemiological data. First FDA employed a standardization of the results by Van Rensburg and extrapolated the incidence expected in the United States from the average and maximum levels of exposure in the southeast. The expected range of cancer incidences per year were 0.37 to 3.74/100,000. The actual rate in Alabama and Georgia was 0.97 and 1.18 per 100,000/year, respectively, well within the range predicted from the epidemiological studies.

To reduce the possible error introduced in this model by assuming the background liver cancer rate to be the same in the United States as in the countries of the epidemiological studies, FDA employed a linear, non-logarithmic relationship which suggests a similar crude background rate to that reported for Caucasians in the United States.[25] After converting the estimated incidences of liver cancer into lifetime liver cancer rates, FDA found that at present exposures to aflatoxin, 20.2 persons/100,000 would develop liver cancer in their lifetimes and that at most, the incidence would be 67.0/100,000 lifetimes. FDA then breaks this incidence into that attributable to the aflatoxin in peanuts and that found in corn, an determined that on average, 1.1/100,000 lifetime cases occurred from peanuts and 19.1/100,000 lifetime cases occurred from corn.

The last calculation made by FDA was of the expected reductions in risk due to setting the tolerance at different levels. To determine exposure rates at lower levels, FDA assumed that the average level of aflatoxins actually found in products is directly proportional to the legal maximum level. When the legal limit is 20 ppb, the actual level is 2 ppb; a legal limit of 15 ppb results in 1.5 ppb, etc. Thus a legal level of 20 ppb results in 1.1-2.7 cases per 100,000 per lifetime. Lowering the limit to 15 ppb lowers the incidence to 0.8.1/10^5/lifetime; to 10 ppb, lowers the incidence to 1.5-1.3/10^5 lifetime; and to 5 ppb in peanut products, to 0.3-0.7/10^5 lifetime. (See Table A-4). These are only minor improvements in the national health.

The Cost of Reducing the Aflatoxin Guideline

Because the peanut industry must expend additional effort to reduce aflatoxin levels as specified by FDA, peanut products will become more expensive. The costs of the regulation are represented by the lost value to consumers and producers resulting from these price increases. To estimate these costs, one must know the original supply function for peanut products, the new supply function reflecting the additional effort needed to reduce aflatoxin levels, and the demand curve for peanut products. In addition, if society believes a particular distribution of wealth to be desirable, it is important to know the extent to which a price increase is disadvantageous to lower income groups if it denies them an inexpensive source of protein.

FDA has yet to issue a cost analysis of its proposed 15 ppb tolerance limit. Its discussion of costs was limited to the statement that since "93 percent of the lots of peanut butter and 97 percent of the lots of other peanut products could meet the 15 ppb level . . . [this level would not cause] significantly increased losses of food."[26] It based this conclusion on "An Assessment of the Effects of Possible Aflatoxin Guideline Changes for the Peanut Industry" by Arthur D. Little, Inc. (ADL), done for the National Peanut Council, a trade association for the peanut industry.[27] This report estimated how much the peanut butter industry would have to pay to meet various aflatoxin guidelines.

ADL Cost Estimates--

The ADL study looked solely at the additional costs associated with the production of peanut butter at various guideline levels. The additional costs were defined in terms of value of the peanut butter which is found to have a higher

TABLE A-4

ESTIMATED LIFETIME CANCER RATES BASED ON EPIDEMIOLOGY STUDIES - INCIDENCE RATES PER 100,000[1]

Peanuts2/			Corn3/			Total	
Aflatoxin Level (ppb)	Risks Resulting From Daily Intake4/		Aflatoxin Level (ppb)	Risks Resulting From Daily Intake4/		Risks Resulting from Daily Intake4/	
	Average	Maximum		Average	Maximum	Average	Maximum
2	1.1	2.7	10	19.1	64.3	20.2	67.0
1.5	0.8	2.1	10	19.1	64.3	19.9	66.4
1.0	0.5	1.3	10	19.1	64.3	19.6	65.6
0.5	0.3	0.7	10	19.1	64.3	19.4	65.0

1/ Based on Peers and Linsell. See text.

2/ Aflatoxin levels are those which might be expected in peanuts and peanut products if the tolerance were reduced from the current 20 ppb to 15, 10, and 5 ppb, respectively.

3/ Aflatoxin levels in corn products assumed to be an average of 10 ppb.

4/ Incidence rate per 100,000 population.

From FDA Risk Assessment.

aflatoxin content than specified by the guideline and would therefore have to be thrown away or rejected. These costs (or values) were then distributed over the remaining quantity of acceptable product and expressed as the additional costs (per unit) of producing acceptable product. Table A-5 lists per unit and total costs of five different guideline levels as calculated by ADL.

TABLE A-5

PER UNIT AND TOTAL COSTS TO PEANUT BUTTER INDUSTRY OF VARIOUS AFLATOXIN GUIDELINE LEVELS (AS CALCULATED BY ADL)[1]

Guideline (ppb)	Per Unit Costs of Acceptable Product[2] (¢/lb)	Total Cost[2] (10^6 $)
20	0.6	3.7
15	3.0	17.6
10	9.1	52.6
5	33.9	196.5
2	60.3	348.5

1. Source: Arthur D. Little, Inc., Assessment of the Effects of Possible Aflatoxin Guideline Changes for the Peanut Industry, Draft Report to the National Peanut Council, January 1974.

2. ADL estimated expected values and upper limit values. The figures reported here represent the expected costs.

To calculate the cost estimates provided in Table A-5, ADL required information on the percent of total peanut butter rejected at each guideline level and the cost of producing a pound of peanut butter. The former information was obtained through a survey of 12 manufacturers of peanut butter representing slightly more than 70% of the peanut butter manufactured in the United States. The manufacturers were asked to estimate the cumulative percentage of their January-June 1973 peanut butter production containing levels of aflatoxin from 0 to 20 ppb.

Based on the survey information, ADL constructed a probability density function of peanut butter production which would exceed the proposed guideline. Based on the distributional characteristics of the function, the expected level of product rejection could be calculated for any guideline level. For example, ADL's calculation showed that if peanut butter manufacturers tested peanuts for 7 ppb aflatoxin content (that which would be required to meet a 15 ppb guideline) approximately 5.1 lb out of every 100 lb would have to be rejected.[28] In addition, ADL calculated the average aflatoxin in the acceptable product at any given inspection level. In the case of a 7 ppb inspection level, the (most likely) aflatoxin level would be an average of 2.0 ppb, but ranging from 1.45-2.41 ppb.

To compute the costs of having to reject a specified percent of peanut butter produced, ADL calculated the average direct costs associated with producing a pound of peanut butter. The basis for this cost element was a per unit production cost estimate of 37.4¢/lb.[29] This base number was adjusted by several factors to arrive at the final figure used by ADL. First, the cost of peanut's portion of the base was escalated by 22% to account for cost increases between 1972 and 1974 (no justification was given for the use of this number). Second, 11.2 cents was added to the adjusted base figure (44.9 cents) to account for the increased cost of inspection and disposal of rejected peanuts (based on industry estimates). While ADL suggested that other indirect cost elements (such as loss of sales) should be included, they stated these costs could not be quantified for this study. The final direct and indirect unit cost of rejecting peanut butter used by ADL was 56.1¢/lb.

By combining the average unit cost of rejecting peanut butter with the average percent of peanut butter rejected at any given aflatoxin inspection level, ADL was able to calculate the total cost to industry of a particular guideline level. The steps undertaken to make this estimate are outlined below.

1) Multiply the fraction of total peanut butter production rejected at a given operating level by total 1972 peanut butter production.

2) Taking the total pounds of peanut butter rejected from 1 and multiplying by 56.1¢ (the costs of rejecting peanut butter) calculate total costs of rejected peanut butter.

3) Divide 2 by total acceptable peanut butter (assumes costs of rejected peanut butter will have to be spread remaining product) to yield costs of a particular inspection level in terms of cents per pound of acceptable product.

4) Translate inspection (or operating) level into FDA guideline level. For example, the costs of setting a guideline of 15 ppb are given by the per unit costs of having to reject at an inspection level of 7 ppb.

5) Multiply costs in cents per pound of acceptable product at a given guideline level by total 1972 production of peanut butter to total costs to peanut butter manufacturing industry of complying with a particular guideline level.

ADL's cost data shows how per unit costs increase as the guideline level is made more stringent. While the movement from 20 ppb to 15 ppb to 10 ppb guideline involves increasingly higher costs, they rise at a slower rate. A dramatic increase in costs occurs at guideline levels below 10 ppb. The cost elements were also shown as a function of reduced average aflatoxin level in acceptable peanut butter at each possible guideline level. This information, for several guideline levels, is reproduced in Table A-6.

TABLE A-6

AVERAGE AFLATOXIN LEVEL (PPB) PER POUND OF PEANUT BUTTER[1]

Guideline (ppb)	Average Expected Aflatoxin ppb Level[2]	% Incremental Reduction
20	2.28	
15	2.00	12.3
10	1.57	21.5
5	.78	50.3
2	.42	46.1

1. Source: ADL

2. Throughout the study ADL reported expected values as well as value ranges. This Table reports only the expected value.

Based on their analysis, ADL recommended against any change in the current FDA guidelines, suggesting instead a stronger quality control program.

Analysis of Cost Estimates--

A careful review of the cost estimates provided by ADL highlights several concerns that suggest that costs of reducing the aflatoxin guideline may be lower than expected by FDA. First, since all the cost increase was based on the 1972 production level of 578 million pounds, the decrease in quantity demanded due to a higher price is totally ignored. This leads to an immediate overestimation of the increased production costs of the regulation. This is demonstrated in Figure I where the net effect of a more stringent FDA guideline is assumed to result in a shift in supply of acceptable peanut butter from S_1-S_2 and the vertical distance DB is the per unit increase in price of producing acceptable peanut butter of the new regulation.

In essence, ADL estimated the area P_1DBP" and referred to this area as the increased costs of producing acceptable peanut butter. In fact, the actual production cost increase would be represented by the much smaller area P_2ACP'. The net social costs of the regulation as discussed are another matter and, following Figure A-1, are shown to be the area ABG. Producers lose surpluses, in the short run, of P"BCP', and consumers incur surplus losses of P_2ABP".

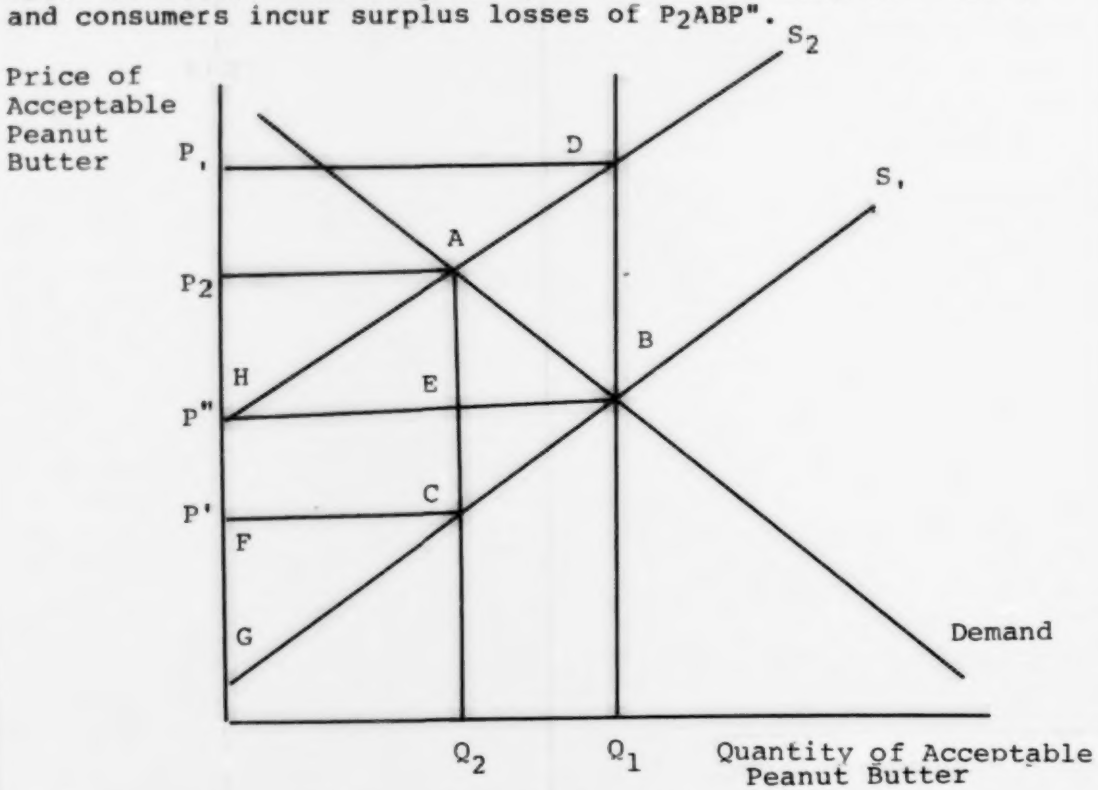

Figure A-I: Illustration of the costs associated with a more stringent FDA aflatoxin guideline.

Second, ADL assumed that the only option available to peanut butter manufacturers for controlling the aflatoxin levels in their products was to reject the unacceptable peanut butter after incurring the production costs of processing. ADL did not allow for the possibility that manufacturers facing a more stringent guideline would require raw peanut shipments with lower average aflatoxin levels than those now received. This assumption was based on a comparison of aflatoxin levels in finished peanuts which showed an extremely low (.003) coefficient of determination between the two. This evidence led ADL to the conclusion that even if shellers produced raw peanuts with lower aflatoxin levels, there would be no effect on the costs imposed on peanut butter manufacturers.

While sufficient information does not exist on the comparison by ADL to allow for a critical appraisal, a review of the report suggests a radically different conclusion. (Even in their study, ADL admitted that logic would argue for a significant positive relationship between raw peanut aflatoxin levels and peanut butter aflatoxin levels.) If a positive correlation between the two did exist, it is likely that a method of complying with new guidelines that involved at least a combination of using cleaner peanuts and rejecting unacceptable peanut butter would yield lower per unit increases in production costs. There is some evidence that FDA may have been aware of this possibility. According to one FDA official, the agency had assumed all along that if they lower their guideline, manufacturers would demand a lower guideline from the USDA for shellers and processors recognizing that lower costs would be incurred than if their only recourse was to reject the final product.

Third, ADL assumed that the costs of meeting the guideline would be incurred each year, and that no technological advances would be made to reduce this cost. Based on the peanut industry's demonstrated ability to develop techniques that reduce aflatoxin levels, an ability shown since the aflatoxin problem was discovered in the 1960s, a more reasonable conclusion is that more technological advances are possible.

Summary--

The estimation of the true social costs of reducing aflatoxin levels in peanuts and peanut products requires several assumptions. First, one has to calculate how a stricter guideline affects the supply curve of the peanut industry. To do this, one must make assumptions about which stage of the process is burdened with the cost. Assuming the cost to be placed on the shellers, one then needs to determine how much of the increase is passed through to consumers. Second, an estimate must be made of how long before technological advances reduce the supply. Third, one needs to determine how strongly consumers react to a price increase in peanuts demand.

The ADL study clearly overestimates the cost of stricter guidelines. It neglected to consider that consumers demand fewer peanut products in response to higher prices and make up part of the loss by substituting other products. Available technology enables shellers to reduce levels far more cheaply than by disposing finished products, as assumed by ADL. Finally, ADL did not make allowances for cost reductions made possible by technological advances.

Supporting the argument that the costs are much lower than ADL's estimates is that the National Peanut Council has subsequently taken a neutral stand toward the 15 ppb guideline. In addition, a FDA official claims that several of the large peanut butter manufacturers have already voluntarily met the 15 ppb even though the regulation is still in the proposed stage.

Footnotes

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2. Miller, James S., "Role of the United States Department of Agriculture." Aflatoxin Quality Control Seminar, National Peanut Council, April 11, 1979.

3. 39 Fed. Reg. 42748, December 6, 1974.

4. Rodricks, Joseph V., Hazards from Nature-Aflatoxins." FDA Consumer, May, 1978.

5. 39 Fed. Reg. 42728, December 6, 1974.

6. U.S. Department of Health, Education, and Welfare, Food and Drug Administration, Bureau of Foods, Assessment of Estimated Risk Resulting from Aflatoxins In Consumer Peanut Products and Other Food Commodities. January 19, 1978.

7. 43 Fed. Reg. 8808, March 3, 1978.

8. Stoloff, Leonard. "Aflatoxins - An Overview." In Mycotoxins In Human and Animal Health. Joseph V. Rodericks, et al., eds., Parke Forest South, Illinois: Pathotox Publishers, 1977.

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12. 42 Fed. Reg. 61630, December 6, 1977.

13. Stoloff, Leonard. U.S. Department of Health, Education, and Welfare, Food and Drug Administration, Bureau of Foods, Personal Communication, November, 1979.

14. Campbell, T. Colin, and Leonard Stoloff. "Implication of Mycotoxins for Human Health." *J. Agr. Food & Chem.*, Vol. 22, No. 6, 1974.

15. *Ibid.*

16. Shank, R.C., *et al.*, "Aflatoxins in Autopsy Specimens from Thai Children with an Acute Disease of Unknown Aetiology." *Fd. Cosmet. Toxicol.*, Vol. 9, pp. 501-507, 1971.

17. Rodricks, *supra*, note 4.

18. Wogan, G.N. "Aflatoxin Carcinogenesis." In *Methods in Cancer Research*, Vol. VII, H. Busch, ed., Academic Press, New York, N.Y., 1973.

19. *Ibid.*

20. Hsieh, D.P.H., *et al.*, "Comparative Metabolism of Aflatoxin." In *Mycotoxins In Human and Animal Health*, Joseph V. Rodricks, *et al.*, eds., Parke Forest South, Illinois: Pathotox Publishers, 1977.

21. Van Rensburg, J. "Role of Epidemiology In the Elucidation of Mycotoxin Health Risks." In *Mycotoxins In Human and Animal Health*, Joseph V. Rodricks, *et al.*, eds., Parke Forest South, Illinois: Pathotox Publishers, 1977.

22. Campbell and Stoloff, *supra*, note 11.

23. *Ibid.*

24. Stoloff, *supra*, note 10.

25. Peers, F.G., and C.A. Linsell. "Dietary Aflatoxins and Human Primary Liver Cancer," Ann. Nutr. Alim.; 1977, 31, 1005-1018.

26. 39 Fed. Reg. 42750, December 6, 1974.

27. Arthur D. Little, Inc., Assessment of the Effects of Possible Aflatoxin Guideline Changes for the Peanut Industry. Report to National Peanut Council, January 25, 1974.

28. Aflatoxin can be unevenly distributed throughout peanut butter leading to large sampling errors in the inspection results. In order to ensure the safety of their products, peanut butter manufacturers normally discard any products with an aflatoxin level higher than 50% of the FDA guideline.

29. This estimate was obtained by ADL from: Peanut Processing Opportunities, University of Georgia, June 1972.

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SACCHARIN CASE STUDY

Introduction

On April 15, 1977 the Food and Drug Administration (FDA) proposed rules in the Federal Register restricting the use of saccharin, the only remaining artificial sweetener permitted for consumption.[1] Citing laboratory experiments demonstrating that saccharin caused bladder cancer in rats, FDA argued that present consumption levels were hazardous and acted to prohibit uses of saccharin that led to human exposure. The FDA proposed to prohibit the use of saccharin in all foods and beverages, drugs (unless the company could demonstrate an overriding health benefit), cosmetics that might be ingested (such as toothpastes, mouthwashes, and lipsticks), and animal foods and drugs. Even animals not intended for human consumption could not be fed saccharin, since the FDA Commissioner found they derived no therapeutic benefit from it. Under the proposed rules, saccharin in the tablet, powder, and liquid forms known as "table-top sweeteners" would be classed as a drug. FDA was undecided as to whether a prescription would be needed to buy saccharin.

The FDA action to ban saccharin as a food additive, or more precisely to revoke the interim regulations allowing the use of saccharin in food products, was taken under the general safety provisions of the Food Additives Amendment of 1958 and the Delaney Clause of the Federal Food, Drug, and Cosmetic Act.[2] The general safety requirements direct the Secretary to detail the uses for and conditions under which a food additive can be safely used. Furthermore, the Delaney Clause categorically states,

> "... that no additive shall be deemed safe if it is found to induce cancer when ingested by man or animal."[3]

Under the Delaney Clause, once FDA concluded that saccharin was a carcinogen, it had a clear responsibility to ban the substance. Although the inflexible nature of the Delaney Clause has prompted considerable academic and public debate, FDA has denied that the Delaney Clause was the exclusive basis for the action. Stating that the accumulated evidence demonstrated that saccharin was not safe for human consumption, FDA held that the general safety requirements for food additives of the Food, Drug & Cosmetic Act[4] would have prompted FDA action in the absence of the Delaney Clause; the Delaney Clause only reinforced the conclusion.[5]

To restrict the use of saccharin in drugs and cosmetics, FDA followed different sections of the Act and a different rationale; it argued that for these uses, the benefit of saccharin must be weighed against the risks. In the case of cosmetics, the Commissioner held that saccharin use should cease because the benefits were not great enough to outweigh the risks, even though these risks might well be quite small.[6]

Consideration of the use of saccharin in drugs presented a more complicated problem since the benefits were plausible but difficult to evaluate. While FDA recognized that special formulas containing saccharin may be required for diabetics and that in certain drugs saccharin provided substantial health benefits that could not otherwise be obtained in the absence of feasible substitutes, it felt the benefits of saccharin generally did not outweigh the risks. Hence, unless overriding health benefits could be demonstrated, its use in drugs was prohibited.

The Commissioner proposed to consider table-top sweeteners as drugs so that consumers could continue to obtain saccharin. Although saccharin's carcinogenicity prevented its use as a food additive, it did not prevent its use as a drug. The Act's provisions governing the approval of human drugs contain no Delaney Clause equivalent specifically preventing the use of carcinogens in human drug products. FDA would have greater control over table-top sweeteners as drugs than as foods, since each variety would need FDA approval. The law gave FDA leeway to determine whether saccharin should be available over-the-counter or whether a doctor's prescription would be required. The Commissioner had not chosen which option to pursue but was inclined to permit saccharin to be sold over-the-counter.

The determination that saccharin would be prohibited as an ingredient in animal foods and drugs was based on a legislative requirement forbidding such use of any substance found to cause cancer in man or animal unless tests provided that no residue of the substance could be detected in any food derived from animals.[7] Since no assays had been submitted to FDA (or were known to exist by FDA) that showed the lack residue, it banned the use of saccharin in animal foods and drugs.

The FDA finding that saccharin was a carcinogen was based on several scientific and medical studies involving animals and humans. The most persuasive results and those most often referred to by FDA in the proposed regulations were derived from chronic toxicity feeding experiments on rats. Two studies of this sort, completed in 1973, one by FDA and another by the Wisconsin Alumni Research Foundation, showed a statistically significant increase in the incidence of bladder cancer in male rats fed saccharin.[8] The results of these studies, however, were of questionable merit and could not be taken as conclusive because the saccharin contained impurities. A third study, sponsored by the Canadian government, corrected the errors in the earlier studies and led to the conclusion that ingestion of saccharin by rats caused an increased incidence of malignant bladder tumors.[9] Extrapolating these results to humans prompted FDA to conclude that saccharin posed "a significant risk of cancer for humans."[10]

By FDA's calculation, the benefit from banning saccharin was a maximum of 4 fewer cases of bladder cancer in the lifetime of 10,000 persons, compared with a lifetime risk of bladder cancer in the United States of 150 cases per 10,000 persons. It has been argued that for this reduction in cancer incidence, the proposed regulations would impose several costs on consumers. In the absence of any non-nutritive sweetener replacement, it was argued, diabetics would have more difficulty obtaining sweet foods and more difficulty adhering to their diets; people would gain weight, becoming prone to other serious health problems such as heart disease and diabetes; and, people would have increased tooth decay. The cost of these effects is hard to evaluate because none have been scientifically proven.

Subsequent events suggested that Congress and FDA had either overestimated the value society places on reducing the risk of cancer or underestimated the value of saccharin's benefits. The public and industry voiced strong opposition to the ban, sending nearly 70,000 letters to the White House, Congress and FDA. After listening to testimony from the American Diabetes Association, the Calorie Council and the Pharmaceutical Manufacturers Association, among others, Congress placed a moratorium on saccharin regulations until May 23, 1979. On July 4, 1979 the House voted to amend the Act by extending the moratorium until June 30, 1981. The moratorium now awaits Senate approval. In the interim, the use of saccharin continues. FDA continues to support removing saccharin from the food supply, except as a table-top sweetener, but is not acting until Congress decides whether, and if so, under what conditions, unsafe food additives perceived to have benefits should be available to consumers.

During the moratorium, the merits of saccharin and the proposed ban have been much debated. More scientific studies have been completed, studies of the scientific studies have been done, as well as studies on many of the political, legal and economic dimensions of the problem. The prevailing opinion is that some intermediate position between unrestricted use and the controls proposed by FDA in 1977 is appropriate. The final solution will probably not be known for some time.

The Benefit of Removing Saccharin from Consumer Products

The health risks of saccharin consumption have been a matter of contention since shortly after saccharin's discovery in 1879. Serious evidence of health hazard, though, did not appear until 1951 when the first of many animal chronic toxicity studies was conducted. Whereas, this study found abnormalities in the abdomen of the rats, the results were not statistically significant, and therefore inconclusive. Since that time, dozens of investigations have taken place. Although scientists are now in general agreement that saccharin is a potentially weak carcinogen in humans, questions remain concerning the medical and scientific evidence.

There are three general types of studies that are used to identify potential carcinogens: epidemiological studies, animal studies and short-term tests. Epidemiological studies involve the comparison of statistics on the incidence and mortality rates of a disease within a human population in an attempt to determine causality. Animal studies expose animals to a single substance over a long period and then examine them for tumors. Short-term tests have been recently developed which are much faster and cheaper than animal or epidemiological studies. They expose bacteria or mammalian cells to the questionable substance to determine if genetic alterations or neoplastic transformation occur. Although a positive result is not conclusive evidence of a substance's carcinogenicity, it indicates that animal and epidemiological studies should be undertaken.[11] Each type of study has been conducted on saccharin. The differing reports reflect the strengths and weaknesses of their respective methodologies. The results of these tests and the uncertainties associated with their results are discussed in more detail below.

Animal Studies--

The 1977 FDA case that saccharin be considered a carcinogen was largely built on the results of three animal studies. The general procedures for these studies, as specified in the National Cancer Institute guidelines, is to administer the maximum tolerated dose of saccharin and one-half or one-quarter of this amount to separate groups of animals. The guidelines specify that the two test groups be composed of fifty males and fifty females each, and 100 animals be in the control group. At the end of the expected lifetime the animals are killed and autopsied, and the results between the experimental and control groups are compared. In addition, the three animal studies which found saccharin to be carcinogenic continued the test for two generations; the second generation was thus exposed from the time of inception.

In 1973, the results of two two-generation studies, one by the FDA and the other by the Wisconsin Alumni Research

Foundation (WARF), were released. Both studies found a statistically significant increase in bladder tumors among second-generation male rats fed the highest levels of saccharin - 7.5% and 5.0% of the diet respectively. However the saccharin used in both experiments contained numerous impurities, making it unclear whether saccharin or an impurity was the cancer-causing substance.[12] This confusion was addressed by a Canadian government two-generation study which investigated the carcinogenicity of the principal impurity in saccharin, orthotoluenesulfonamide (OTS). One group of rats was fed a 5% dose level of saccharin without OTS, other groups were fed various levels of OTS. The rats exposed to saccharin developed bladder tumors, while those fed OTS exhibited no adverse health effects.[13] None of the eleven one-generation animal studies that have been conducted on saccharin have revealed harmful effects.[14]

Several areas of uncertainty exist in interpreting the results of animal studies. One is how to interpret results obtained by purposely administering extremely high doses of a substance to test for its carcinogenicity. While many non-scientists have criticized this method of testing, it is held to be appropriate among scientists. Without using exaggerated doses animal tests would not be sensitive to mild carcinogens; for example, a 300-animal test would only be able to detect a carcinogen expected to affect 1% of the population, or 2 million persons, in the United States. But if the doses are several magnitudes higher than realistic doses, effects can be extrapolated for approximately 0.001% of a population, or two thousand people in the United States. At the same time, the dose must not be so high as to cause acute, noncancerous toxic effects. While some reviewers felt that the 5% and 7.5% dose levels in the saccharin studies could have been toxic, the National Academy of Sciences panel concluded they were not.

Concluding that the use of high dose levels in animal studies is justified does not remove the uncertainty associated with their use; the appropriate method of extrapolating effects from high to low doses is not clear. Estimates of response at low doses differ radically depending on which model is used. Of the two major models, the single-hit or straight line model predicts response to be much greater in the low-dose range than the log-normal model. When the dose level is one thousandth of a dose at which 50% of the population develops cancer, the single-hit model predicts response to be 200 times greater than the log-normal model.[15] (Table A-7). FDA used the single-hit model in estimating the risk of saccharin.[16]

TABLE A-7

EXPECTED RESPONSE RATES AS A FUNCTION OF DOSE FOR DIFFERENT DOSE-RESPONSE MODELS[a]

Relative Dose	Log Normal, %	Log Logistic, %	Single Hit, %
16	98	96	99 +
8	93	92	99
4	84	84	94
2	69	70	75
1	50	50	50
.50	31	30	50
.25	16	16	29
.125	7	8	16
.063	2	4	8
			4
0.01	.05	.4	.7
0.001	.00035	.026	.07
0.0001	.0000001	.0016	.007

Source: National Academy of Sciences, Saccharin: Technical Assessment of Risks and Benefits, Washington, D.C., 1978.

A second uncertainty involves extrapolating health effects from animals to humans. Several critical factors may differ among species that would cause some to be hypersensitive to a substance and others to be resistant. These factors include metabolic pathways, rates of biotransformation, rates of repair and routes of excretion.[17] Some substances will cause cancer in different organs in different species. Nevertheless, the NAS panel of scientists concluded that "since the metabolic pattern of organs or tissues and their responses to acute injury are often very similar among different species, it is not surprising that chemicals that are shown to be carcinogenic in one species often show the same type of response in other species."[18] Supporting this statement is the finding that 81 of the 82 known human carcinogens have been shown to induce cancer in animals.[19] In defending its saccharin decision, FDA acknowledged the uncertainty in using results from animal tests to identify human carcinogens. It then accepted the principle, after citing similar positions taken by numerous experts and government health agencies.

Beyond the inherent uncertainties of all animal studies, the results of the saccharin two-generation studies generate additional policy questions. First, almost without exception, the cancers noted in these studies developed only in rats which were exposed to saccharin in the womb and throughout their early development. Several factors make the fetus radically moe sensitive to cancer-causing agents than adults. These factors include suggestions that transplacental transfer results in higher doses to the fetus than to the mother, the unknown strength of the fetus' immunities, the possibility of greater susceptibility during rapid development, different fetal metabolic capacities than adults, and factors relating to fetal pharmacology.[20] The importance of second generational health effects is not in question since pregnant women may expose their children to saccharin. Rather, the question is how these results should be used to predict health effects on adults.

Second, only male rats exposed to saccharin showed statistically significant increases in the incidence of bladder cancer. This calls to question the appropriateness of applying the risk predictions to human females since the prediction cannot even be applied to female rats of the same strain.[21]

A final uncertainty is whether saccharin acts in concert with other substances to increase the probability of cancer. Mondal et al. (1979) found it may be a weak promoter in a study which obtained significant in vitro transformations of cells exposed to saccharin in the presence of nontransforming doses of the carcinogen and an in vitro transforming agent, 3-methylcholanthrene.[22]

Epidemiological Studies--

The usefulness of the epidemiological studies on saccharin as a guide to policy making is extremely limited by methodological difficulties. The first study to suggest that saccharin presents a health hazard was completed soon after the FDA proposal.[23] This was a case-control study in which the differences in artificial sweetener consumption between people with bladder cancer and healthy people were compared, controlling for age and residential neighborhood. The study found an increased risk of bladder cancer for men who consume artificial sweeteners but not for women consumers. As it did not differentiate between artificial sweeteners, the study could not attribute the risk to saccharin alone. A similar case-control study did not find a risk associated with the use of saccharin.[24] The NAS panel concluded that methodological difficulties prevented them from judging the "seemingly contradictory results" of these two studies. In addition, four other case-control studies failed to show a correlation between saccharin consumption and bladder cancer, but they were found by the panel to contain such significant methodological problems that conclusions could not be made from the results.[25]

Two other types of epidemiological studies have been conducted on saccharin. One is time-trend analysis in which trends in exposure to a substance are compared to trends in the incidence of a disease. The two studies of this type failed to detect any correlation between saccharin use and the incidence of bladder cancer, although like the case studies described above, shortcomings suggest caution in relying on these results. A study of bladder cancer rates in Britain, where saccharin consumption became extensive during World War II, found that saccharin's contribution to the increased rates could not be statistically separated from that of cigarette smoking.[26] The second study, in the United States from 1950 to 1967 where a dramatic increase in the consumption of saccharin occurred in 1962, noted that the study may have taken place too soon to detect the effects of the increase in consumption because carcinogens are thought to have a latency period of 18 to 45 years.[27]

The third type of epidemiological study on saccharin compared the incidence of bladder cancer among diabetics with that of the general population. Diabetics tend to consume large quantities of saccharin as a substitute for sugar. None of these studies have found significant differences in bladder cancer rates among the test groups.[28] However, diabetics differ from the general population in several key ways that might effect the validity of the test results such as metabolism, genetics, diet, abnormal bladder function, and a tendency to smoke less.[29] Given these differences, diabetics cannot be assumed to be equivalent to nondiabetics in all things except saccharin consumption.

The above discussion suggests several methodological limitations to epidemiological studies that must be taken into account when applying the results of these studies to regulatory policy. First, they are most useful at detecting extremely potent carcinogens. Increasing their sensitivity can only be done by expanding the sample size which generally requires large expenditures. Second, it is difficult to control for the health effects of other carcinogens and other social and environmental variables, restricting the ability of the rests to isolate the risk of one carcinogen from other factors. Third, the long latency period for most carcinogens may render impractical the dependence on epidemiological tests for evaluating suspected carcinogens unless they have been part of the environment for many years.

Summary--

FDA relied heavily on the results of the two-generation animal studies in determining saccharin to be carcinogenic.

There is little doubt that these tests support their conclusion: that saccharin acting alone is a weak carcinogen. However, the risk is apparently very small; they estimated that, between zero and 4 out of 100,000 people would develop cancer from saccharin in their lifetimes. Alternatively stated, between zero and 1,200 people in the United States would develop bladder cancer each year should everyone consume one diet soda a day.[30] These estimates rank saccharin as the weakest carcinogen yet discovered. More serious than the health effects of saccharin on adult humans are the health risks to human fetuses, children, the mutagenic risks to the gene pool and its potential promotional or carcinogenic effects.

The Cost of Regulation

The economic definition of the cost of regulation is the value of foregone alternatives. In the case of a ban on saccharin, the costs are represented by the lost sales resulting from price increases for dietetic foods and beverages, and the transition costs of switching labor and capital from the production of products containing saccharin to other products.

FDA considered two costs: the increased price of sugarless products, and the value of lost sales of saccharin and products containing saccharin. It found the total cost of the proposed regulation to range from $715.0 - $2,079.6 million.[31]

Of this total, FDA estimated the lost sales to industry to be between $607.2 - $1,969.3 million including the diet food, diet beverage and table-top sweetener industries, and to the sole domestic producer of saccharin, Sherwin Williams. The lower figure assumes some reduction in lost sales through the offering of alternative products formulated with small amounts of nutritive sweeteners. These would be consumed only by overweight people, not diabetics. The higher figure represents a complete loss in which no diet foods, diet beverages or table-top sweeteners are purchased, either because no alternative sweeteners are found or consumers do not buy any that are marketed.

The costs of prohibiting the use of saccharin in drugs, where saccharin is an inactive ingredient, were estimated separately by the Bureau of Drugs.[32] The implied conclusion was that no major costs would be imposed on the drug industry. The FDA finding was based on several assumptions. (1) Many drugs are formulated with other sweetening agents besides saccharin, which suggests that these sweeteners could be used in drug products containing saccharin. (2) FDA felt that other "substitute sweeteners will almost certainly be found."[33] (3) In addition, FDA reasoned that the dosage form of drugs would not have to be altered, a costly aspect argued by industry, since a film coating could be applied to drugs to make them more palatable. FDA did admit that some increased packaging costs would be incurred by the drug industry because of larger tablet sizes.

On a graph, the value of the lost sales to the industries are repreeesented by the area OP_0RQ_0; the price times the quantity sold (See Figure A-2).

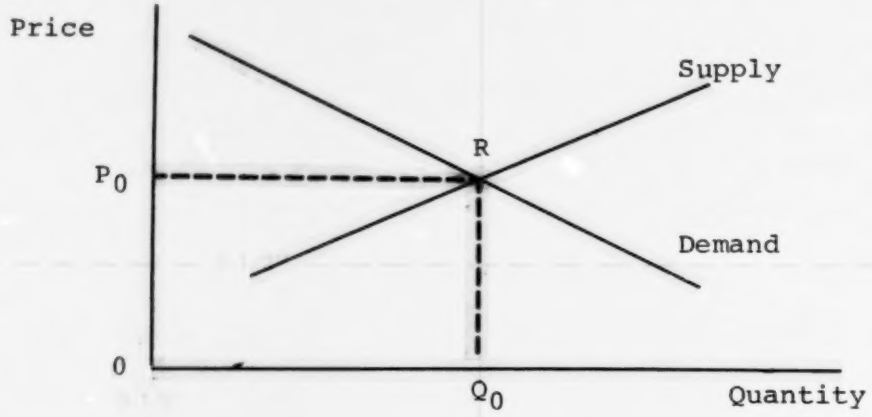

Figure A-2: Market equilibrium for saccharin products.

The value of lost sales, though, is not an accurate estimate of the cost of the regulation since the resources previously used in the production of products containing saccharin are transferred to other productive uses and therefore generate other sales. In the short-run some resources such as plant facilities are fixed and will lie idle; the production lost by the idle capacity is a short-run cost, as are the costs incurred in transforming resources into new productive uses. In the long-run, resources will be fully employed in the second most valuable use. The long-run cost is the difference between the value of products containing saccharin and the value of the second best use of the inputs. This cost will be much lower than those represented by lost sales.

FDA estimated the cost to consumers to range from \$107.8 - \$110.3 million. These figures were derived by. assuming diet foods and beverages would be reformulated using nutritive sweeteners and would be purchased only by overweight people. Furthermore, the increased price of products containing alternative sweeteners was assumed to approximate the price of substituting sugar for saccharin.

While FDA's method is the beginning of an assessment of the cost to consumers, it falls several steps short of a theoretically appropriate estimate. In order to estimate the true social costs of the regulation, the lost consumer surplus, one must have estimates of the supply and demand functions for dietetic products. The increased costs to industry that FDA estimated will actually be translated into a new price for sugarless dietetic products through the workings of the market. Once a new price is estimated, the lost consumer surplus can be calculated, with the knowledge of how much lower demand for a product is when its price increases. In Figure A-3, the lost consumer surplus is represented by the trapezoid P_0P_1TR.

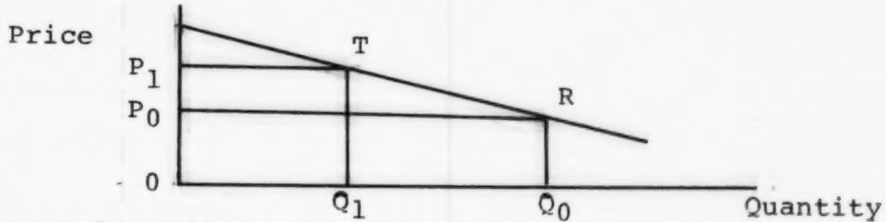

Figure A-3. Effect of price increases for dietetic products.

The Council on Wage and Price Stability (CWPS) estimated that, based on the concept of lost consumers' surplus, the regulation would cost $144 to $182 million. This assumes that all the surplus presently enjoyed by consumers would be lost and that the demand for saccharin was relatively inelastic. Neither of these assumptions seems likely to be true in the face of subsequent evidence. First, not all of consumers' surplus would be lost since several alternative products could replace saccharin in consumers' market basket: new alternative sweeteners could be approved for use, consumption of existing alternative sweeteners could be increased, or diet foods and beverages could be reformulated without any sweeteners to which consumers would add saccharin they would buy as a table-top sweetener. Second, the demand for saccharin is not likely to be as inelastic as assumed by CWPS since the demand is not for saccharin as such, but for qualities provided by saccharin. Since other products provide these qualities, the appropriate definition of the demand curve is demand for low-calorie, sugarless sweeteners. Thus, with a ban on saccharin, consumers will lose only a part of the surplus associated with consumption of low-calorie sugarless products, and the actual dollar amount will be smaller than that estimated by CWPS.

The actual costs imposed on consumers, as implied by the above discussion, depends on the value consumers impute to the benefits of consuming products containing saccharin, whether actual or perceived, and whether alternative sweeteners are seen as close substitutes. The vigorous protest following the proposal to regulate the consumption of saccharin that came from members of the public, the medical profession and industry suggests that these benefits may be quite large and that alternatives were not perceived as being as effective. Because of the important role played by consumers' perceptions of the benefits of saccharin, and their validity, to accurate cost estimates, a review of the evidence on the existence of these benefits is presented below.

Saccharin in Foods and Beverages--

One of the greatest areas of concern to the public was the elimination of saccharin from foods and beverages. Studies have shown that the preference for sweet foods exists from the time of birth.[34] Furthermore, the quantity of sweets consumed appears to be culturally determined, and in the United States sweet foods are an increasing proportion of the diet. Sugar adds what are commonly cited as "empty" calories to food and beverage products. These calories are quickly converted to fatty tissue when calorie consumption exceed the body's needs, thus promoting weight gain.

Saccharin is most frequently cited as facilitating weight loss and helping diabetics avoid sugar reactions. For those wishing to control their weight, saccharin provides the sweet taste of sugar without the calories. Diabetics react both acutely and chronically to nutritive sweeteners such as sugar. Saccharin, a non-nutritive sweetener, as in foods and beverages provides these individuals an opportunity and to indulge a taste for sweetness and to participate more fully in social situations. Furthermore, people who develop diabetes in adulthood are typically overweight. For them saccharin plays an additional role, in so far as it is thought to aid in weight reduction, an important component of their treatment. As an assessment of saccharin's contribution in controlling weight, some predicted that in its absence the American population as a whole would gain 632 million pounds of fat in one year. To the extent that people would gain weight, such health problems associated with obesity as heart disease, diabetes and ironically cancer, would also increase.[35]

Saccharin in Drugs--

Saccharin is used as an ingredient in many types of drugs to sweeten and mask the taste of medicine. For example, saccharin is frequently added to liquids and chewable tablets for users, particularly children, who have difficulty swallowing pills. The underlying intent of formulating prescription and over-the-counter drugs with saccharin is to encourage people to comply with directions involving their use. Failure to follow the recommended dosages, is recognized as "one of the key problems in attaining desired therapeutic results" of drugs.[36]

In many drugs, sugar is not a viable substitute for saccharin. If sugar is chemically active with other ingredients in a drug to which it is added, it can destroy the therapeutic value of the drug. Because sugar is chemically unstable, it can also reduce the life of the product. Moreover, the quantity of sugar necessary to mask the bitter taste of some drugs may be so large as to make the size of pills unmanageable were sugar used to replace saccharin. Finally, using sugar as an ingredient in drugs represents a potential hazard to diabetics.

Saccharin in Cosmetics--

In toothpaste and mouthwashes, the major perceived advantage of saccharin is that it encourages proper dental care. A sweetener is useful in toothpastes because of the bitterness of fluoride and the chalkiness of phosphates.[37] Adding sugar would contravene the purpose of using toothpastes as well as present the same sort of technical problems arising from its use in drugs.

Scientific Evidence of Benefits--

Few studies have attempted to measure the extent to which the benefits discussed above are in fact realized. A panel of scientists at the National Academy of Sciences reviewed several studies and concluded that:

1. Research has yet to be conducted to determine the effectiveness of saccharin in controlling weight, making it impossible to evaluate this perceived benefit;

2. Few studies have investigated saccharin's role in weight reduction, and those that exist have been unable to document that it contributes significantly to weight loss. Two studies that found saccharin to contribute to weight loss had such limitations that no confidence could be placed in their findings.[38] Two other studies found no correlation between weight loss and the use of non-nutritive sweeteners.[39]

3. No evidence indicates saccharin to be necessary in the diabetic diet. Current theories stress control of calories rather than sugars, and suggest that carbohydrates represent 40% to 60% of the diet. Diet, combined with regular eating schedules, moderate quantities of food and regular exercise is the recommended lifestyle for diabetics. The use of saccharin does not seem to encourage better adherence to the dietetic regime.[40] However, saccharin may provide substantial benefits by adding variety, assuaging a sweet tooth, and offering a psychological crutch.

4. Although adequate studies have not been conducted, saccharin does appear to play an indirect role in preventing tooth decay.

5. And there are possible benefits in including saccharin in drugs and cosmetics.

Although no other non-nutritive sweeteners are currently permitted for general consumption by FDA, there are several substances that, in the absence of saccharin, might become available as substitutes. In addition, several nutritive sweeteners, such as xylitol and sorbitol, may also be developed as substitutes for saccharin. These substances do not run the same risks to diabetics as ordinary sugars. It should be noted that none of the known possible alternatives to saccharin are without some questions of health risk and many are, at this point, commercially inferior to saccharin as a food additive.

Summary--

The estimation of the true social costs of the proposed saccharin ban is frustrated by several critical factors which are not easily defined or quantified. First, one has to identify the appropriate market in which changes in equilibrium prices and quantities should be measured. Is this market the one for saccharin, or is it one of a group of substances sharing similar characteristics such as sweetening without adding calories, or causing tooth decay or affecting blood sugar levels. Second, given the definition of the relevant market how inelastic is the demand for products with the attributes of saccharin? Should the demand curve reflect the lack of scientific evidence of benefits attributed to saccharin consumption, or should it reflect the perception of benefits? Third, one has to calculate how a ban on saccharin affects the supply curve in this market. What are the short-run costs incurred when capital is committed to the production of products containing saccharin? How much will it cost to transfer the resources used to make saccharin products into making the second best alternative? What is the long-run loss in producer's surplus measured by the difference between the economic profits from saccharin products and the second-best alternative? How much more costly will alternative sweeteners be to produce? Fourth, since at the time of the proposed ban no perfect substitutes for saccharin existed, the question becomes important of how long before substitutes are ready to market; that is developed, tested, approved, formulated into products and capital readied for production? Need substitutes be developed, or can existing substances such as xylitol and sorbitol readily replace saccharin's role? How much will the consumption of saccharin as a table-top sweetener increase as a result of the proposed regulation?

In light of difficulties imposed by the above considerations, it is not surprising that FDA and CWPS made simplifying assumptions that would bias their estimated cost of the proposed regulation. FDA erroneously included the total cost of lost sales to industry and miscalculated the loss to consumers. CWPS correctly identified lost consumer surplus as the appropriate cost to measure, but made the unreasonable assumption that no alternatives to saccharin would become available. While any estimate is inherently uncertain given the number of assumptions that need to be made, an estimate based on more flexible and appropriate assumptions would almost certainly reveal the cost to be lower than either group predicted.

Chronology

1970	NAS-NRC reviewed all available toxicity data on saccharin for FDA for its GRAS review. Inconclusive. Recommended establishment of 15 mg/kg body weight/day limit, and new studies of chronic effects.
1971	June 25--FDA proposed removal of saccharin from the GRAS list and the establishment of an interim food additive regulation.
1972	February 1--FDA removed saccharin from GRAS.
1973	May 25--Extensions of interim food additive regulation.
1974	December 10--NAS-NRC report concluded that existing evidence does not support a conclusion that saccharin is carcinogenic.
1977	January 7--FDA extended interim food additive regulations until results of Canadian studies available.
	April 15--FDA proposed to prohibit the use of saccharin in diet foods, soft drinks, cosmetics, animal foods, animal drugs, and to permit its use in drugs when the benefits outweigh the risks.
	November 23--Congress passed the Saccharin Study and Labeling Act placing an 18 month moratorium on regulations affecting saccharin.
1979	May 23--Expiration of moratorium.
	July 24--House passes amendment to Saccharin Study and Labeling Act extending the moratorium until June 30, 1981.

Footnotes

1. 42 Fed. Reg. 19996, 1977.

2. 42 Fed. Reg. 20002, 1977.

3. 21 USC §348(c)(3)(A) 1977.

4. 21 USC §348(c).

5. 42 Fed. Reg. 20002, 1977.

6. 42 Fed. Reg. 20005, 1977.

7. 21 USC §306b(d)(1)(H), 1972.

8. U.S. Department of Health, Education, and Welfare, Public Health Service, Food and Drug Administration. *Histopathologic Evaluation of Tissues from Rats Following Continuous Dietary Intake of Sodium Saccharin and Calcium Cyclamate for a Maximum Period of Two Years*, 1973; U.S. Department of Health, Education, and Welfare, Public Health Service, Food and Drug Administration, Division of Pathology. *Subacute and Chronic Toxicity and Carcinogenicity of Various Dose Levels of Sodium Saccharin*, 1973; and Wisconsin Alumnae Research Foundation. *Long Term Saccharin Feeding in Rats*. Madison, Wisconsin: WARF, 1973.

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10. 42 Fed. Reg. 19996, 1977.

11. 44 Fed. Reg. 39859, July 6, 1979. "Scientific Basis for Identification of Potential Carcinogens and Estimation of Risks"; U.S. Environmental Protection Agency, *Short-term Tests for Carcinogens, Mutagens and Other Genotoxic Agents*, July, 1979; and, Maugh, Thomas H., "Chemical Carcinogens: The Scientific Basis for Regulation." *Science*, 201 (1978), 1200-1205.

12. See note 8.

13. Canada, Ottawa, *supra*, note 9.

14. Althoff, J., A. Cardes, P. Pour, and P. Shubik. "A Chronic Study of Artificial Sweeteners in Syrian Golden Hamsters." *Cancer Lett.* 1:21-24; BioResearch Consultants, Inc., *Report to the National Cancer Institute on Studies on Saccharin and Cyclamates*. Cambridge,

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15. National Research Council/National Academy of Sciences. *Saccharin: Technical Assessment of Risks and Benefits*, Washington, D.C.: National Academy of Sciences, 1978.

16. 42 Fed. Reg. 20001, 1977.

17. National Research Council, *supra*, note 15.

18. *Ibid*.

19. Maugh, *supra*, note 11.

20. National Research Council, National Academy of Sciences, *Safety of Saccharin and Sodium Saccharin in the Human Diet*, Washington, D.C.: National Academy of Sciences, 1974.

21. Havender, William R., "Ruminations on a Rat: Saccharin and Human Risk." *Regulation*, March/April, 1979.

22. National Research Council, *supra*, note 15.

23. Howe, *et al.*, "Artificial Sweeteners and Human Bladder Cancer." Lancet, 2 (1977), 578-581.

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RADIATION CASE STUDY

Radiation Regulation

Protection of human populations and the environment from excessive radiation exposure is an area of federal regulation that is characterized by several agencies administering statutes that have been adopted in a piecemeal fashion. No single agency has the authority to coordinate the various radiation protection procedures or to establish the broad principles under which the costs and benefits of alternative levels of radiation protection could be evaluated. Consequently, the agencies responsible for radiation protection have worked largely independently as they weigh the merits of varying degrees of control. The purpose of this study is to review from a cost-benefit perspective some of the practical problems encountered by the agencies as they seek to protect individuals from radiation and to indicate briefly some of the agency responses to these problems.

The radiation of interest to the regulatory agencies is termed ionizing radiation, because as it passes through substances, chemical bonds are broken and electrons are lost. In biological material the damage can kill cells, induce cancer, and produce genetic effects. Ionizing radiation consists of alpha, beta, and neutron particles and gamma and X rays. Mankind is exposed to ionizing radiation from several sources: cosmic radiation, terrestrial radiation, medical diagnostic procedures, and internal radioactive isotopes contributing the most to dosage rates. Table A-8 summarizes the average doses for the U.S. population.

Ionizing Radiation: Scientific Aspects

The several types of ionizing radiation have quite different effects in biological matter and, hence, have different implications for public policy. Alpha particles are positively charged helium particles which are not appreciably absorbed by biologic matter. Thus, alpha particles emanating from the environment are stopped by the outer dead layer of human skin. Beta particles are negatively charged and may penetrate to a few centimeters in biological matter. As alpha and beta radiations do not easily penetrate tissue, an adverse effect by these radiations would most likely occur only when the radionuclides are inhaled or ingested by an organism and the radiations are emitted inside the organism. Alpha and beta particles are termed internal emitters. Neutrons are uncharged particles that may penetrate deeply into biological tissues before causing ionization. Gamma and x radiations are similar to the radiations of the visible spectrum, expect that they have much shorter wavelengths. These radiations easily penetrate tissues, to the extent that they may go right

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TABLE A-8

1970 ESTIMATED WHOLE BODY DOSE RATES IN THE U.S.

Source of radiation	Average dose in millirems/year
Natural	
Cosmic	45
Terrestial	60
Internal Isotopes	25
Manmade	
Global fallout	4
Nuclear power	0.003
Medical diagnostic	72
Radiopharmaceuticals	1
Occupational	0.8
Miscellaneous	2

Source: Nuclear Poser Issues and Choices, p. 163.

through an exposed organism. Gamma and x radiations and neutrons are termed external emitters, as they may evoke an adverse effect without being inhaled or ingested by the organism.[1]

Alpha and beta radiations are said to be "directly ionizing" as they carry a charge and directly interact with atoms in biologic tissues to cause ionizations. Conversely, neutron, gamma, and x radiations are said to be "indirectly ionizing" in that, although they are uncharged, their energy is released to produce charged particles which, in turn, interact with atoms in biologic tissues and cause ionizations. For example, collisions between neutrons and atoms in biologic tissues may cause the formation of positively charged particles, termed protons. These protons, so formed, may pass through the exposed tissue causing ionizations.[2]

The damage to biologic matter by ionizing radiation depends on the amount of energy lost by the radiation. The more energy lost, the more ionization and hence, damage. The phrase, linear energy transfer (LET), is the amount of energy lost by the ionizing radiation per unit distance transversed. The LET value, usually expressed in kiloelectron volts (keV)/micrometer (um), of a particular type of ionizing radiation increases as the energy decreases.[3] For example, an alpha particle with an energy of 100 keV will have a lower tissue penetration distance but a higher LET value than an alpha particle with an energy content of 200 keV. Beta particles and gamma and x rays are low-LET radiations and are responsible for most of the absorbed doses received by the general population and by radiation workers.[4] Neutron radiation and alpha particles are high-LET radiations.

To better understand the biologic effects of ionizing radiation, a brief discussion of the units of measurement is warranted. Basically, one can measure either the amount of radionuclide or the radiation dose. The quantity of radioactive substance can be determined by the number of radioactive disintegrations per second for a given amount of radionuclide. The basic unit of quantity of radionuclides is the curie (Ci), which is the amount of material in which 3.7 X 10^{10} atoms disintegrate per second. The actual weight of radioisotope comprising a curie varies.[5] For radium-226, the naturally occurring radioisotope of radium 3.6 x 10^{10} disintegrates/second are emitted from 1 gram of material. The curie indicates the number of radiations being emitted, but does not indicate a biological effect.[6]

The radiation does is measured in roentgens, rads, or rems. The oldest unit of measurement, the roentgen (R) is applicable only to gamma and x radiations. The more current terminologies are the rad and the rem. The rad, or radiation absorbed dose, is the amount of radiation which leads to the absorption of 100 ergs of energy/gram of absorbing material. However, a rad of exposure to alpha particles has a greater biological effect than a rad of x radiation. To account for differences in the biological effectiveness of different kinds of ionizing radiation, the rem (for roentgen equivalent man) is used as a unit of "relative biological effectiveness" (RBE). One rem = (1 rad) (RBE), where RBE is used as a correction factor to convert rads to rems, which is a measure of exposure independent of the type of radiation. Typical RBE values are 1 for gamma and beta radiations with energies above 50 keV, 2 to 5 for lower energy gamma and beta radiations, 10 for fast neutrols and natural alpha particles, and 20 for fission particles.[7]

Lastly, the man-rem (or, person-rem) is used to measure the exposure of a population to ionizing radiation. It is defined as the added doses, i.e., those above background levels, to which the population is exposed. For example, 200 people exposed to 2 rems each of ionizing radiation would be measured as 400 man-rems.[8]

Ionizing radiations naturally occur in the biosphere and constitute the background radiation to which the biota is, presumably, adapted. This background radiation is derived from nuclides located in the external environment or in the organism itself.

Cosmic radiation consists of charged particles, primarily protons and some heavier particles. However, upon entering the earth's atmosphere, these charged particles collide with atmospheric gases to produce a variety of products, including neutrons, gamma rays, mesons (positively or negatively charged particles of intermediate mass between that of protons and electrons), and electrons.[9] The dosage of cosmic radiation received by an individual is dependent on the altitude. For example, at sea level the radiation dosage is about 40 millirems (mrems)/year, but at Leadville, Colorado, at an altitude of 3 kilometers (km), the dosage increases to 160 mrems/year. At an altitude of 10 km the dosage is 3,500 mrems/year. Altitude becomes a significant factor for aircraft crew and passengers. It has been estimated that a transcontinental jet flight at a height of 10 km would result in an extra whole-body radiation dose of 1 mrem.[10] For the U.S. population as a whole, aircraft transportation results in a cumulative does of 105,350 person-rems/year.[11]

Radionuclides in soil and in building materials are additional sources of ionizing radiation, with concentrations varying according to soil types. Thus, the rate at which a person receives ionizing radiation from terrestrial sources is dependent on the soil type of the specific geographic location. Individuals living in the Atlantic and gulf coastal plain states receive terrestial radiation at levels from 15 to 35 mrem/year; those in the northeastern, central and far-western states received from 35 to 75 mrem/year; and those in the Colorado plateau region received from 75 to 140 mrems/year (Figure A-4)[12] Braziliansoils rich in thorium and uranium emit quantities of radiation causing whole body exposures up to 2,000 mrem/year.[13]

Natural radionuclides may be ingested or inhaled by organisms and, thereby, are present in the body tissues themselves. The level of "internal" radionuclides is depenent on geographical location, the type of water supply, etc.

Artifical (i.e., anthropogenic) sources of ionizing radiation include those from medical/dental treatments, radioactive fallout, occupational exposure, and a variety of minor sources. X rays, used either for medical/dental diagnoses or for therapy, constitute the largest anthropogenic course of exposure of the U.S. population. It was estimated that in 1970, 65% of the U.S. population was exposed to x rays for medical/dental purposes.[14] Another medical source of ionizing radiation occurs in patients administered radiopharmaceuticals.

Beginning in the 1950s, another source of ionizing radiation arose, that from the radioactive fallout resulting from the testing of nuclear weapons. When a nuclear weapon is tested in the atmosphere, extensive local fallout of radioactive materials occurs for 1 day over the immediate area. However, worldwide trophospheric fallout is evident for about 1 month and worldwide stratespheric fallout occurs for many years thereafter.[15]

Occupational exposure to ionizing radiation occurs during the operation of x ray equipment in medicine and dentistry. Operators of medical x ray equipment are exposed to an additional 125 mrem/year. Medical radionuclide and radium workers are exposed to an additional 350 and 540 mrem/year, respectively. Personnel associated with commercial nuclear power plants and supporting activities, such as the mining and milling of uranium, are also exposed to additional ionizing radiations. Research activities utilizing high voltage x ray machines, particle accelerators, x ray diffraction units, neutron generators, and electron microscopes are other potential sources of exposure to ionizing radiation.[16]

Minor sources of ionizing radiation include various consumer products (e.g., luminous wristwatches and clocks, smoke detectors, television sets) and activities (e.g., smoking, combustion of natural gas during cooking, combustion of fossil fuels for home heating) and industrial products (e.g., building materials, airport luggage x ray inspection systems). These sources yield a combined whole-body dosage exposure for the U.S. population of 4 to 5 mrems/year.[17]

Traditionally, the adverse biologic effects of ionizing radiation have been classified as (1) genetic and (2) somatic. A genetic effect is an adverse effect occurring in the germ cells, i.e., the sperm and the egg. Such an adverse effect, involving some gene mutation or chromosomal aberration, may be transmitted to (i.e., inherited by) the offspring. This type of damage poses a threat to the descendents of the exposed individual. Somatic cells are all the body cells, except the germ cells, comprising an individual. An adverse effect on a somatic cell poses a threat to the exposed individual. Chromosomes with their genes control not only the hereditary aspects but also the everyday metabolic activities of the cell. Thus, an adverse effect on somatic cells may also (as with the germ cells) be due to the induction of gene mutations or chromosomal aberrations.[18]

The biological damage caused by ionizing radiation results from the disruption of molecules, such as DNA, which are essential to the normal functioning of cells. Densely ionizing, high-LET radiations are most effective at damaging cells, possibly because they have a high probability of emitting large amounts of energies into small volumes. Radiations having low-LET spread their energy out more or less uniformly in the cells, so that no portion of the target cell receives large quantities of energy.[19]

Ionizing radiations may interact in a variety of modes with cells: (1) The radiation may pass through the cell without causing intracellular damage. (2) The ionizing radiation may cause sublethal damage to the cell, which can eventually repair and recover from the injury. (3) The radiation may damage the cell to the extent that the cell cannot repair the injury or it reproduces itself in an altered physiological state.[20]

Although much research has demonstrated the genetic effect of ionizing radiation on microorganisms, plants, insects (primarily, the fruitfly), laboratory animals (with emphasis on the mouse), and cells in tissue culture,[21] there is an almost complete absence of information on radiation-induced mutations in human beings. The problems of recognizing and of estimating the effects of ionizing radiation on genetic effects has been stated by the National Research Council:[22] "Some results of genetic change are conspicuous, others are invisible; some are tragic, others so mild as to be trivial; some occur in the first generation following the gene or chromosome change, others are postponed tens or hundreds of generations into the future. Furthermore, most of the effects that are produced by mutation are mimicked by others, of nongenetic origin. For all these reasons, radiations (or some other environmental agent) could be having an important effect on human well-being, yet this could go unnoticed. Even if the increase in mutation rate is large, the consequences are likely to be so heterogeneous in their nature, so diluted by space and time, and so obscured by similar conditions from other causes as to make it impossible to associate with their cause."

The somatic effects caused in ionizing radiation include impairment of early human growth and development, impairment of fertility, formation of cataracts, promotion of the aging process, and induction of cancer. The development individual, i.e., the embryonic, fetal and infant stages, is especially sensitive to the damaging effects of ionizing radiation. Knowledge of the effects of ionizing radiation on human development is derived from 4 sources: (1) patients irradiated for medical reasons, (2) the survivors of the atomic bombs dropped on Hiroshima and Nagasaki, (3) the individuals of the Marshall Islands who were exposed in 1954 to radioactive fallout,[23] and (4) studies of population exposed to high levels of background radiation. A high incidence of microcephaly (i.e., a head size of reduced circumference), with or without accompanying mental retardation, was noted in subjects exposed *in utero* at Hiroshima and Nagasaki. Elevated rates of chromosomal abnormalities were noted among survivors and their offspring who were exposed *in utero* but not in the children conceived after the detonation of the atomic bomb.[24] A high incidence of fetal and neonatal mortality was also noted. At Nagasaki, the rate of fetal deaths was 23.4% and that of neonatal or infant deaths was 26% in those situated 2,000 meters from the point of detonation.[25]

The most definitive studies on the hypersensitivity of children to ionizing radiation were of young children exposed at Hiroshima and examined into adolescence. Decreased growth rates and body measurements characterized those children exposed to 100 rads or more. People of the Marshall Islands who were exposed to radioactive fallout in early childhood developed atrophy of the thyroid gland, with impaired body growth and sluggish mental functions.[26]

The induction of cataracts, the promotion of premature aging, and the impairment of fertility as somatic effects of ionizing radiation have been noted primarily in studies with experimental animals. There are little data on humans and some of the data is contradictory. For example, mortality studies of radiologists have demonstrated increased mortality rates from cardiovascular-renal diseases as compared to other medical technologists, strengthening the notion of radiation-accelerated aging. However, accelerated aging has not been noted in studies of the survivors of Hiroshima and Nagasaki.[27]

Lastly, but perhaps of greater concern, are the effects of ionizing radiation on cancer induction. Although the mechanism of carcinogenesis is not fully known, there are several hypotheses concerning the mode of induction of malignant tumors by ionizing radiations. Ionizing radiations may (a) cause gene mutations in somatic cells, (b) cause chromosomal aberrations which are a dominant feature in malignant cells, (c) activate latent intracellular oncogenic viruses, (d) cause a precancerous lesion in which tissue regeneration leads to cancer, and (e) damage an endocrine gland, such as the pituitary, so that a hormonal imbalance is created that causes a cancer at another site, such as the ovary.[28]

Different biologic tissues have different sensitivities to ionizing radiation, with progenitive tissue being the most sensitive. (Table A-9) Progenitive tissues include the bloodforming components, the alimentary tract mucosa, the skin and associated structures, and the lens of the eye.

Many studies have demonstrated a positive relationship between ionizing radiation and cancer induction in humans. An increased incidence of all forms of leukemia (except for

TABLE A-9

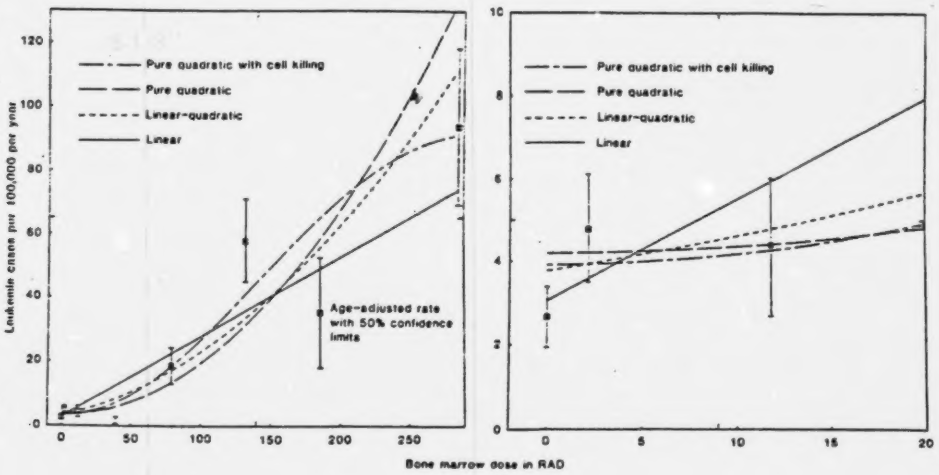
Tissues are listed here in the order of their decreasing radiosensitivity (Grosch and Hopwood, 1979):

1. Lymph tissue, especially lymphocytes
2. White blood cells and immature red blood cells of the bone marrow
3. Cells lining the gastrointestinal tract
4. Gonadic cells
5. Skin, especially the proliferating layer
6. Blood vessels and the body cavity lining
7. Tissues of glands and the liver
8. Connective tissues
9. Muscle
10. Nerves

chronic lymphocytic leukemia) was noted in atomic bomb survivors of Hiroshima and Nagasaki and in British patients treated with intensive spinal irradiation for ankylosing spondylitis[29]. Overall, the risk for leukemia in the survivors of the atomic bombs was about 20 cases/million people/rad/year. Increases in other types of cancer were also noted among the survivors; the risk, in cases/million people/rad/year, was 1.2 for thyroid cancer, 2.1 for breast cancer, and 2.0 for lung cancer.[30] An increase in the incidence of bone tumors was noted in the 1920's in painters of luminous dial watches and clocks. The workers, unknowledgeable of the adverse effects of radiation, often dipped their brushes into the luminous compound which contained radium, and then tipped their brushes on their tongues. Radium miners, who often are exposed to and inhale radioactive dusts and gases, have a high incidence of lung cancer.[31]

The Regulatory Problem

The problem facing regulatory agencies is to develop sensible policies regarding exposure to relatively low doses of radiation. Tabe A-8 indicated that doses from manmade sources are below background levels of radiation for most of the U.S. population. Given that the human population has probably adapted for the most part to background levels, it is not surprising that difficulties are encountered in measuring the effects of small increases and natural background levels. Perhaps the most attention has been given to long term studies of the survivors of the Nagasaki and Hiroshima A-bombings. The data on radiation exposures are unique in having a wide range of exposures and a large sample size. Although the sample size at low levels of exposure is not sufficient to determine with any precision the impacts of low doses, the effects at higher doses can be extrapolated. Figure A-4 below indicates a range of possible extrapolations, based upon linear, quadratic, and other functional forms of the dose response function. All functional forms are consistent with the prevailing scientific opinion that no threshhold exists, that some cancer risk is present for even very small elevations in background radiation levels. Even so, the estimated dose-response relationship at low doses depends heavily on which functional form is chosen.



Source: Science, September 12, 1980, p. 1200.

Figure A-4. Dose-response analysis of leukemia incidence among Nagasaki A-bomb survivors.

A recent Chinese study provides supporting evidence on the effects of low doses of radiation.[32] Since 1972, the

Chinese team has monitored the health status of approximately 73,000 people who live in parts of Yangjiang County, Guangdong Province, where background radiation levels are about three times those in neighboring areas, and the health status of about 77,000 people in two control regions a few kilometers away. Population exposures averaged approximately 25 millirems/month in the high-background area and 9.3 millirems/month in the control areas. Comparison of blood samples for chromosomal aberrations, the spontaneous abortion rate, heredity diseases and congenital abnormalities, and the growth and development of children showed no significant difference between the two regions. Likewise, the mortality rate from malignancies did not show a significant difference between the two regions for the period 1970 through 1974. The Chinese concluded that to detect the effects of relatively low doses (such as the approximately 200 millirem difference in background radiation doses in the study), a much larger sample must be used.

Other studies of the effects of low level radiation include the studies by Thomas Mancuso and associates of workers at Hanford, observation by Najarian and Colton of workers at the Portsmouth Naval Shipyard where nuclear submarines are maintained and refueled, and the work of Irwin Bross on diagnostic x-rays. All of these studies claim that there is an elevation of cancer incidence even at low levels of radiation exposure. But just how great is the elevation in risk remains uncertain. Two difficulties are always encountered. First, precise direct estimation of risks at small doses requires impractically large samples. Second, to estimate low-dose risks from high dose data, must depend heavily on parameters in the dose-response curve, e.g., whether it is linear, quadratic, concave, or convex in the region of low doses.

The currently accepted approximation, developed by the International Commission for Radiological Protection (ICRP), is that a whole-body dose of 1 rem leads to a death risk of one in ten thousand. A less reliable but quantitatively similar estimate holds for the risk of a serious genetic effect. The dose-response function is assumed by the ICRP to be linear. That is, the ICRP assumes that 10 rem exposures of 1,000 individuals and .01 rem exposure of one million people will both have a death risk of one person.

In this context, the Chinese study of 70,000 people, each of whom is exposed to approximately 0.2 rems of excess background radiation relative to the control group, should find about 1-1/2 excess deaths per year in the study group. Such a small effect would likely go undetected in samples this size.

Using the ICRP data, one can make a rough estimate of the number of cancers per year caused by all manmade sources of

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radiation in the U.S. (1,800). Of this number, nuclear power contributes 0.1, global fallout 22, occupational sources 4, and medical diagnostic cases over 1,700.

Several dimensions of the federal regulatory problem should be apparent now. First, there is probably no totally safe level of exposure to radiation. Thus, statutes that direct agencies to reduce risks to the maximum extent feasible push agencies toward a zero increment to background levels. Second, the dose-response relationship at low levels is highly uncertain. Actual fatalities from a given dose could vary by more than one order of magnitude about the best estimate available. Third, it may be very costly to control exposures to radiation. These costs may be expressed in terms of labor and capital needed to shield a reactor, in terms of excess risks to other workers to supply the necessary shielding (which could more than offset the expected savings from radiation protection), or in terms of less precise medical diagnoses if medical exposures are reduced. The need for some balancing of costs and benefits should be clear.

Were this the full extent of the radiation regulatory problem, this case study would look much like saccharin, aflatoxin, or coke oven emissions. There is another dimension of the radiation problem that makes it considerably more intractible, however. This factor is the long term activity of many radioactive materials. Relative long-run activity for radioactive materials is measured in terms of half life, the time required for half of the radioactive nuclei in a substance to decay. Half lives for some of the materials produced in nuclear power reactors range up to one hundred thousand years, indicating a considerable risk to human populations should these substances be released to the environment. The dilemma facing regulators is how to evaluate these future risks. Should the risk of one cancer one hundred years from now be treated the same as the same risk today? Should future risks be discounted? Although the issue may seem trivial, a risk of one fatality per year for the next million years is valued quite differently when a zero discount rate is used (1 million fatalities) than when a more conventional rate such as ten percent is used (only ten fatalities in present value terms). The implications for public policy are enormous. In the no-discount case agencies would be pressed to limit all future releases of radioactive substances, while in the more conventional case they can be more cavalier about future effects.

The EPA environmental impact statement for regulations on the uranium fuel cycle clearly demonstrates these issues.

EPA was given the authority to address public health and environmental concerns arising from radiation exposure in the uranium fuel cycle in The President's Reorganization Act No. 3 of 1970. The environmental aspects of the uranium fuel cycle concern the long-term irreversible commitments of radioactive pollutants into the earth, atmosphere, and water. The uranium fuel cycle consists of three phases: fuel supply, electrical power generation, and fuel reprocessing.[33] Each phase has the potential of contributing radioactive effluents into the environment. The first phase, or fuel supply, consists of a series of operations extending from mining through the fabrication of enriched uranium into fuel. The fuel supply phase results in the introduction of naturally occurring radioactive materials into the environment through mining, milling, and fabricating uranium from ore. The primary environmental hazard concerns the immediate release of particulate radioactive materials into the atmosphere and water. The maximum potential doses to the lung and bone from the fuel cycle occur at mills and fuel fabrication facilities, due to the release of dust containing natural or enriched uranium. Radioactive particulates may also enter environmental pathways, such as ingestion through food chains, and result in a long-term buildup of radionuclides in the environment.

The second phase of the uranium fuel cycle concerns the power reactor, where fuel is fissioned to produce electricity. The environmental hazards surrounding this phase concern operational releases of radioactive wastes into the confines of the reactor, from which there is a potential for pollution of the atmosphere. The radioactive wastes originate from the fission process which unlocks radioactive gases, such as iodine-131, krypton-85, uranium-238, thorium and plutonium. Under certain conditions, inert dust contained in cooling air may be discharged into the atmosphere.

The final phase of the uranium fuel cycle comprises fuel reprocessing, in which spent fuel elements are broken down in order to isolate radioactive wastes. At the present time no reprocessing plants are operating and none will operate in the future unless the political climate changes, but they do represent the largest potential source of environmental contamination. During this phase, the fuel cladding is broken up and all remaining fission products may potentially be released into the atmosphere. As an example, during the process of separating unfissioned uranium 238 and plutonium 239 from radioactive waste products, two radionuclides, krypton 85 and tritium, are released. Krypton 85 accumulates in the atmosphere causing increased particulate radiation. Tritium, the radionuclide of hydrogen, is present in water vapor. Because of the difficulty of removing tritium from liquid discharges from reprocessing plants, tritium enters the water and may concentrate in fish in increasing amounts in the food chain. Iodine, which accumulates in the thyroid, also may be released into the atmosphere from the reprocessing cycle.

It should be noted that standards for waste disposal are being developed separately by NRC and the EPA. The large potential environmental harm from leaking storage and disposal facilities has helped to delay the promulgation of these standards until better scientific data can be developed.

In developing its standards for the uranium fuel cycle, the agency was careful to attempt to balance costs and effects, and in effect argued that expenditures up to a range of $500,000 to $1,000,000 to save a statistical life were reasonable. The agency adopted a curious position with respect to the present value of future effects, however, when it used a zero discount rate to compute the present value of effects up to the year 2000 (the next 23 years when the EIS was prepared) and chose not to count any effects beyond that date (in effect a 100% discount rate). Why this arbitrary position was taken was not explained or defended.

Cohen investigated the implicit cost per life saved in the context of other radiation protective regulations. A summary is included in Table A-10. That the costs per life saved are so large relative to the recommendations of Martin Baily and others suggests greater attention to costs and benefits should be given in federal regulatory actions to regulate radiation exposures.

TABLE A-10
COST PER FATALITY SAVED

Regulation/Action	Dollars per Fatality Averted
Radium in drinking water	$ 2,500,000
OMB guidelines	7,000,000
Defense high level waste	200,000,000
Civilian high level waste	
No discounting	18,000,000
Discounting 1% per year	1,000,000,000

Source: Health Physics, 38, p. 36.

Examination of other federal regulatory actions to limit radiation exposures reveals similar anomalies. The geographical area in which effects are counted may matter as much as

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discounting. In its attempt to assess the impacts of long-term storage options for defense wastes, the Department of Energy cited a 50-mile limit to the validity of its dispersion models and limited the calculation of adverse health effects to those occurring within a 50-mile radius of the proposed disposal sites. In effect, this sharply reduced the apparent risk because most repositories are in relatively isolated areas. If DOD was able to project exposures world-wide from leaks in long-term storage facilities, the need for better containment would probably appear quite urgent. Likewise, by arbitrarily cutting off from consideration any effects beyond the year 2050, DOD removed from its shoulders much of the problem with the integrity of its containment and the long-term risks from plutonium and other long-lived alpha emitters.

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27. NAS, supra, note 2.

28. Grosch and Hopwood, supra, note 21.

29. NRC, supra, note 22.

30. Grosch and Hopwood, supra, note 21.

31. Pizzarello, supra, note 19.

32. High Background Radiation Research Group, "Health Survey in High Background Areas of China," Science, August 22, 1980, pp. 877-880.

33. United States Nuclear Regulatory Commission, Radiation Standards Fact Sheet, 1980.

APPENDIX B

CASE STUDIES OF HAZARDOUS WASTE DISPOSAL

INTRODUCTION

Up to this point, this report has discussed hazardous waste issues on a conceptual level. As much as this was necessary for our analyses, the value of the study lies in the applicability of the study results to existing situations. One way to assess this applicability is to examine actual incidences of improper disposal of hazardous waste and see how the cases support the analyses of the study. The five case studies included in this section have already been used in the previous sections to support various parts of the analyses. This section will present them in their entirety and discuss some of their common elements.

We will examine five cases involving hazardous waste disposal: two incidents, in New Jersey and North Carolina, of illegal dumping of hazardous wastes; two incidents, in Kentucky and Pennsylvania, of abandoned hazardous waste sites, and one incident, in Illinois, involving siting of a hazardous waste disposal facility. The North Carolina case study also deals with the siting issue.

SELECTION AND METHODOLOGY

We selected candidate incidents from a variety of sources. Foremost was the list of 138 incidents of toxic substances-related pollution incidents in connection with another study. This study, Six Case Studies of Compensation for Toxic Substances Pollution: Alabama, California, Michigan, Missouri, New Jersey, and Texas, was completed by the Environmental Law Institute and published under the same title by the Senate Committee on Environment and Public Works in June of 1980 (96th Congress, 2nd Session, Serial No. 96-13). Other sources included newspapers and other periodicals, and the EPA preliminary damage assessments. In choosing the case study incidents from the candidate list, we looked for incidents that:

1. Illustrate the issues involved in illegal disposal, abandoned sites, or siting of disposal facilities;

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2. Had caused substantial harm to people, property, and the environment; and

3. Had been well documented and on which information was readily available (recent incidents, because less information is available on them, thus tended not to be selected).

In researching the five cases, we relied on a number of sources, including newspaper and periodical accounts, government documents, court pleadings, and interviews with principal actors.

ORGANIZATION OF CASE STUDIES

After an introduction, the case studies are divided into two main sections: one dealing with background information on the cases and the other with the costs, both private and social, imposed by hazardous waste disposal.

For the four cases dealing with illegal waste disposal and abandoned waste sites, the Background Information section is divided into the following subsections:

Location

This gives pertinent geographic and geologic information on the waste disposal site.

Waste Disposal

This discusses the specifics of the waste disposal and is further subdivided as dictated by the logic of the individual cases.

Response

Here is detailed the reaction by local, state, and federal authorities and private parties to the waste disposal. It includes investigation of the extent of pollution, action to protect public health, administrative enforcement action, and criminal and civil suits.

The Background Information section for the case dealing with the siting of a hazardous waste facility in Wilsonville, Illinois is subdivided in a different manner to reflect the different subject matter.

The section on costs first analyzes the private costs incurred as a result of illegal waste disposal, an abandoned dump, or the siting of a disposal facility, according to the case under consideration. For cases involving illegal dis-

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posal of hazardous waste, this section compares the actual cost of illegal disposal with what it would have cost to properly dispose of the wastes.

The costs section next assesses the social costs incurred as a result of the waste disposal. For illegal disposal and abandoned sites, these include injury to natural resources, property, and health, enforcement and litigation costs, and clean-up costs. For the siting cases, social costs are divided into the social cost of having the site, which includes injury to natural resources, property, and health, and the social cost of not having the site, which is the cost borne by society as a result of losing a hazardous waste disposal facility.

STUDY RESULTS

We found that there is generally a long delay between discovery of a threat to public health or the environment posed by improper waste disposal and removal of the threat. In fact, in three of the four cases considered here, the hazardous waste situation has not been remedied and continues to threaten the environment.

In two of the cases this delay partially stemmed from slowness on the part of government officials in enforcing applicable laws. People living near the Wade site complained for two years to Chester City officials about pollution from the site, but no action was taken, possibly because the city is not responsible for enforcing the environmental laws.

Kentucky state officials knew of problems at the Valley of the Drums as long ago as 1967, but did not begin administrative proceedings against the operator of the site until April 1976, after much complaining by adjoining landowners. Nothing resulted from these proceedings until August 1978, over two years later, because of an oversight on the part of the hearing officer.

In these same two cases, lack of resources has prevented cleanup of the disposal site. In both cases the parties responsible for the dumping do not have the means to pay for cleanup. In the Chester, Pennsylvania case both the hauler and the dumper are bankrupt; in the Kentucky case, the hauler/dumper is dead and his estate would almost certainly declare bankruptcy if a judgment were entered against it. Litigation has not been able to hasten cleanup in either case. EPA has sued to force the parties responsible in the Chester case to clean up the site, but the suit has not yet been scheduled for trial, over a year after it was filed. Moreover, the suit was not filed until almost two years after

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the problems at the site were discovered. In Kentucky, the state filed an administrative complaint against the widow of the site operator a year-and-a-half ago, but the state has not pursued the complaint because it feels that to do so would be fruitless.

Government has been able to spend only limited funds to help speed cleanup in these cases. In Chester, the state government is paying for a partial cleanup that began nearly three years after discovery of problems at the site. In Kentucky, the federal government provided emergency response funds to contain the immediate hazards posed by the site, but neither federal nor state government has funds to pay for a complete cleanup of the site.

Because of these factors, only partial cleanup efforts are underway at these two sites. Cleanup is still outstanding over three years after discovery of the Chester site, and four years after the first administrative proceedings in the Kentucky case.

Lack of resources is not the reason for delay in cleaning up the PCB contamination in North Carolina. The state is willing and able to pay to remove the PCB contamination from the roadways and dispose of it in a specially constructed landfill, but public opposition in the county where the landfill would be located has blocked the state's path. Two years after the dumping, the contaminated soil still has not been removed.

The pollution in the Dover Township, New Jersey case was quickly cleaned up. Cleanup was instigated not by government but by the owner of the land on which the wastes had been dumped, who sued to have the hauler and the generator of the wastes remove them. The court ordered the responsible parties to do so the day the suit was filed, and the site was cleaned up within three months of its discovery. The reason for the quick cleanup in Dover Township may be that only one company had generated the waste. The company was easily identifiable and did not contest the court's order to remove the waste. In contrast, several companies generated the wastes in the Chester, Pennsylvania and Kentucky cases, and the companies for the most part cannot be linked with the wastes they generated.

In the cases we studied, the costs of improper hazardous waste disposal generally were not borne by the persons responsible for the disposal. Instead, government generallly had to pay for cleanup and private parties--neighboring landowners and residents--have suffered uncompensated injuries.

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In Pennsylvania, the state government is paying for a partial cleanup of the Chester site; the federal government has paid to contain pollution from the Kentucky site; the New Jersey state government paid for emergency drinking water supplies and testing of groundwater in the Dover Township case; and the North Carolina state government plans to pay to clean-up the dumped PCBs. So far, these governments have not recovered their expenditures from the parties responsible for the dumping.

In all these cases, private parties have suffered injuries including lowered property values, loss of drinking water, loss of gardens and crops, acute health effects, and possible latent health effects. In all but the New Jersey case, private parties have not received compensation for these injuries.

It seems unlikely that government or private parties will be able to obtain compensation from the persons responsible for the dumping. The responsible parties in the Chester case are bankrupt; in the Kentucky case, the hauler/dumper is dead and his estate is poor; in North Carolina, the hauler has limited resources, although the generator of the wastes might be able to pay for damages.

In two of the cases, some of the costs of improper dumping have been assumed by the responsible parties. In Kentucky, waste generators are paying to remove some of their wastes from the dumpsite. However, their efforts will cost less than $100,000 or 4% of the $2.5 million estimated cost of a complete cleanup. The most extensive compensation was received in the Dover Township, New Jersey case. The generator of the waste paid households in the contaminated area $1,000 each as compensation for injuries suffered. Whether this is sufficient to cover all injuries that may result from the contamination, including possible future health effects, is uncertain. The generator is also compensating the state government for up to $60,000 of costs incurred over a five-year period starting three years after the incident first came to light. The generator is not reimbursing the state for the substantial costs it incurred before that period nor is it compensating the township or the federal government for their expenditures.

These case studies were conducted in 1980. In October 1981, the Institute reviewed and updated the case studies, incorporating any charges in the status of federal and state court cases. In addition, we have noted, where possible, the effect that passage of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 has had on prospects for remedial action.

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PETROCHEMICAL CONTAMINATION OF COHANSEY AQUIFER, DOVER TOWNSHIP, NEW JERSEY

Introduction

Between March and December 1971 Nicholas Fernicola, a scavenger trucker under contract to the Union Carbide Corporation disposed of between 5,000 and 6,000 barrels of chemical wastes from Union Carbide's Bound Brook, New Jersey plant on a former chicken farm in Dover Township, New Jersey and in the township landfill. The wastes included aromatic hydrocarbons, benzene, toluene, styrene, xylene, ketones, alcohols, and phenolic resins.

In early 1972, the township and the owner of the chicken farm obtained a court order directing Union Carbide to remove the wastes from the township.

Groundwater contamination in the township was first discovered in early 1974, when residents complained that their well water had a disagreeable taste and odor. Numerous tests found high levels of organic chemicals in the well water. For the most part, the tests did not permit a precise characterization of the contaminants. However, phenol, styrene, and toluene were found in the well water.

In September 1974 residents were provided with an interim water supply. The Township Board of Health ordered the 148 wells in the area with contaminated groundwater sealed at the owners' expense. Shortly thereafter a nearby municipal water system was extended into Pleasant Plains.

In 1976, thirteen additional wells near the affected area were found to be contaminated and were condemned. The municipal water system was subsequently extended to the area.

Both area residents and the State of New Jersey, in separate actons, sued Union Carbide for compensation. Both cases were settled. Affected well owners or users received $1,000 each for the loss of their wells, and the state will receive up to $60,000 as compensation for costs incurred as a result of the contamination.

Background Information

The Location--

Dover Township, population 64,000, is located in Ocean County in the center of the New Jersey coast. Pleasant

Plains, the site of the illegal dumping and subsequent groundwater pollution, is a residential community in the northwest corner of the township.

Several aquifers underlie the township. The most important of these is the Cohansey Formation, estimated to be between 50 to over 100 feet thick in the portion below the Township.[1] This aquifer is the prime source of drinking water for the residents of the township and surrounding areas. Beneath the Cohansey lies another important aquifer, the Kirkwood Formation. Groundwater in the portion of the Cohansey Formation underlying Dover Township moves in a southerly to southwesterly direction.[2]

Union Carbide is a multinational manufacturer of industrial chemicals, plastics and consumer goods. In 1971 Union Carbide had sales of $3,037,529,000 and total assets of $3,554,668,000, and employed 99,181 persons, 52,906 of them in the United States.[3] Exact information on Fernicola's waste hauling business is not available, but it was reported to be very small, consisting of just Fernicola and a few employees.[4]

Waste Disposal--

In April 1971, the Union Carbide Corporation contracted with Nicholas Fernicola, a local scavenger trucker, to remove and dispose of drummed chemical wastes from its Bound Brook, New Jersey plant at a rate of $3.50 per drum. The wastes consisted of solvents and residues from the manufacture of organic chemicals, plastics, and resins,[6] and may have included aromatic hydrocarbons, benzene, toluene, styrene, xylene, ketone, alcohols, trichloroethylene, acrylonitrile and phenolic resins.[7] Since many of these wastes are solvents that were used to wash equipment, they might also have contained other unknown substances.[8] Many of the chemicals identified in the wastes that Fermicola hauled from the Union Carbide plant qualify as hazardous under the hazard criteria that the National Academy of Sciences has developed for the Coast Guard for the evaluation of the hazards of bulk water transportation of chemicals. The chemicals in the waste are hazardous on account of their ignitability, irritativeness, toxicity to humans or aquatic life, or reactivity to other chemicals.[9]

Fernicola hauled approximately 6,000 drums of waste from the Bound Brook plant during the period April 1971 through December 1971.[10] According to Union Carbide, Fernicola claimed that he was dumping these wastes in the Dover Township landfill, situated approximately 45 miles south of the Bound Brook plant and 1-1/2 miles to the northeast of Pleasant Plains (see Figure B-2).[11] The township landfill does not charge for the use of its facilities. Fernicola is believed

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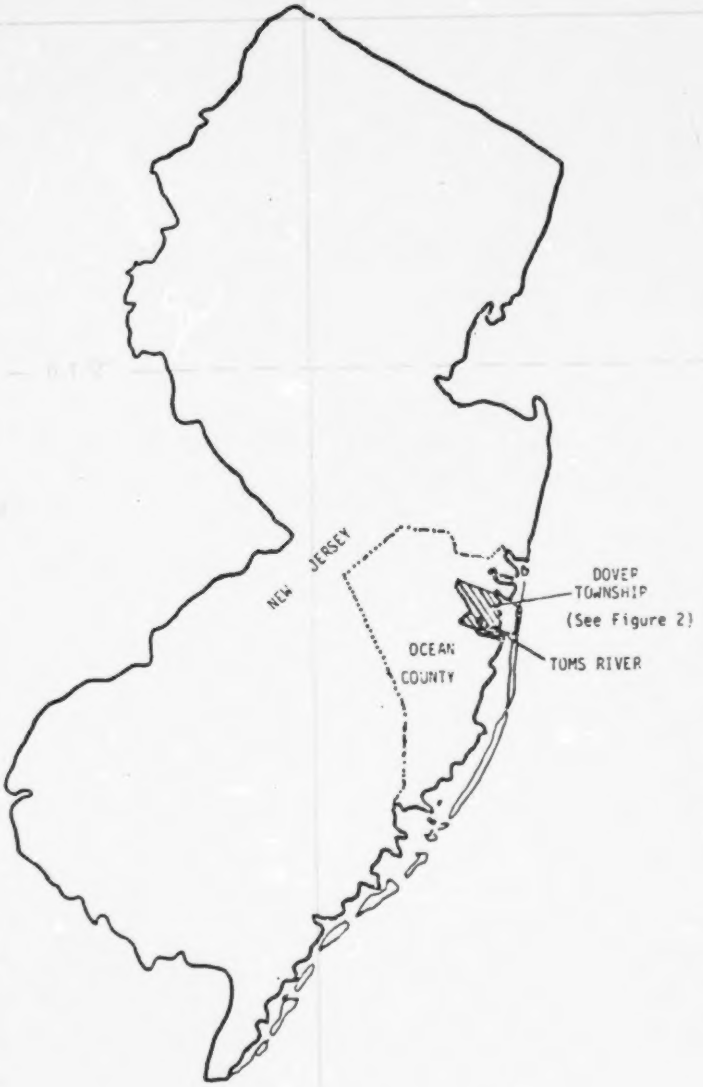
NEW JERSEY
DOVER TOWNSHIP
(See Figure 2)
OCEAN COUNTY
TOMS RIVER

Figure B-1. Locations of Ocean County, Dover Township, and Toms River in the State of New Jersey

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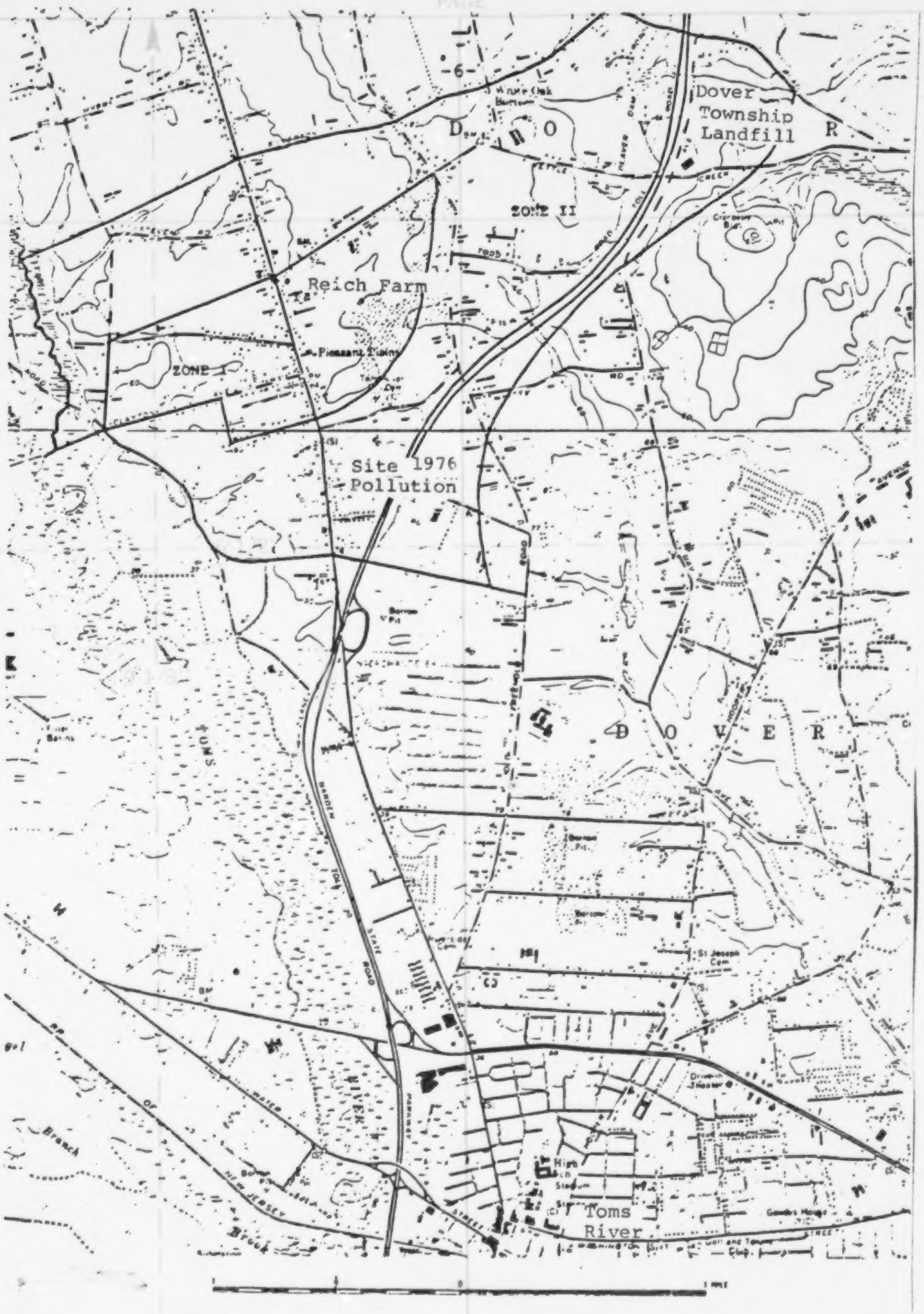
Dover
Township
Landfill
D O R
ZONE II
Reich Farm
Pleasant Plains
ZONE I
Site 1976
Pollution
D O V E R
TOMS
RIVER
Toms
River
1 MILE

Figure B-2. Location of Reich Farm, Dover Township

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to have dumped around 2,000 drums of waste in the landfill, even though it has a policy against accepting drums or chemical wastes, and in other neighboring landfills.[12] Fernicola disposed of the majority of the wastes--approximately 4,500 drums--on a portion of a chicken farm in Pleasant Plains which he had leased from Samuel and Berta Reich, the farm's owners.[13] The Reichs leased Fernicola the property for $40 per month with the understanding that he would use it to temporarily store empty drums. No mention was made of disposing chemical wastes.[14]

Much of the waste was disposed of simply by scattering the drums around the Reich farm; a portion of it, however, was poured directly onto the ground, into trenches dug especially for that purpose.[15] Approximately ten percent of the drums found on the Reich farm were partially or completely empty; presumably, their contents had been discharged to the ground.[16]

Response--

Discovery of waste disposal; cleanup--The Reichs discovered that Fernicola was dumping waste on their property in December 1971 after noticing unusual odors emanating from the site. The Reichs asked Fernicola to remove the wastes. When Fernicola failed to do so despite repeated assurances, the Reichs, on January 31, 1972, filed a complaint against Fernicola and Union Carbide demanding that further disposal stop, the drums be removed, and that other relief be provided. Dover Township also filed a complaint against Fernicola and Union Carbide that day, charging that the situation on the Reich farm constituted a public nuisance.[17] The same day the suits were filed, the court ordered the two defendants to stop the dumping and to remove the wastes from the Reich's farm.[18]

By April 1972, Union Carbide had apparently removed all the drums from the Reich farm, transporting them to incinerators in New Jersey and Ohio and approved chemical waste landfills. Once this cleanup had been effected, the complaints against the defendants were dismissed with prejudice.[19] In addition, the Reichs were reported to have received from Union Carbide $10,000 in an out-of-court settlement for damage to their property, and compensation for the costs of digging a new well.[20]

Enforcement action in response to dumping--The state did not take action against Fernicola or Union Carbide to enforce the waste disposal laws while the dumping was taking place or even once the dumping was discovered, but waited until the groundwater contamination discussed below was discovered several years after the dumping. The state might have proceeded against Fernicola and Union Carbide under several regulations, however. At the time of the dumping, the Department of Environmental Protection (DEP) and the Board of Public Utility Commissioners regulated waste disposal.

Beginning in 1970, DEP required haulers of solid waste to register themselves with the Department.[21] Registration involved only answering a few simple questions; no registration fee was charged,[22] nor did DEP require haulers to meet any minimum standards.[23] DEP also regulated landfills, requiring that they be registered and their designs approved.[24]

The Board of Public Utility Commissioners (PUC) started regulating waste haulers as common carriers in 1971.[25] PUC regulations required waste haulers and disposers to hold a certificate of public convenience and necessity from PUC; to obtain this certificate, a hauler or disposer had to furnish a statement of his experience, training or education in solid waste disposal and proof of financial responsibility.[26] Meeting these requirements would have cost a hauler an estimated several hundred dollars in 1971, including a $50 filing fee and the services of an accountant and a lawyer.[27]

Fernicola had not registered as a waste hauler with either DEP or PUC, making his activities illegal. The Reich farm was an illegal disposal site, never having been registered with or approved by DEP for such purposes.

Union Carbide apparently did not investigate whether Fernicola had met the registration requirements when it entered into its contract with him. As part of the contract, however, Union Carbide did require Fernicola to guarantee that the wastes would be taken to an authorized landfill.[28]

Neither DEP's nor PUC's regulations regarding waste disposal were well enforced at the time the dumping in Dover Township took place. DEP's regulation on waste disposal took effect July 1, 1970. In 1971, the time the dumping took place, DEP had a staff of five to enforce the regulations for the entire state,[29] and was just beginning to develop enforcement strategies.

PUC's regulations took effect July 8, 1971, after the Dover Township dumping had gotten underway. During 1971, PUC was trying simply to identify waste haulers and get them to register. Enforcement staff was just beginning to be hired, and very little effort was made to catch persons not complying with the regulations.[30]

The likelihood that a person violating DEP's and PUC's regulations would be caught must therefore be assessed as slight. The maximum penalty for violating DEP's regulations was $2,500 per day.[31] The penalty for a first violation of the PUC regulation was $500 and up to $1,000 for subsequent violations.[32]

Discovery of groundwater contamination--Groundwater contamination in Dover Township was first discovered in early 1974, when three Pleasant Plains families in the vicinity of the Reich farm noticed that their well water had a foul taste and odor.[33] Tests revealed traces of toluene in the well water from one property and phenol in the water from the other two.[34] The property owners whose wells were contaminated with phenol dug new wells and found uncontaminated water.[35] The owner of the property with the toluene-contaminated well apparently did not want to dig a new well and instead evicted his five tenants since he could not provide them with pure water.[36]

Shortly thereafter the Board of Health received a report of contaminated water in other sites several miles from the properties where the pollution was first reported, but only a few hundred feet from the Dover Township landfill. Tests confirmed that water in three wells near the landfill was contaminated with phenols.[37]

From March to August, 1974, local, state, and federal agencies tested samples of well water from Pleasant Plains using several test procedures. Most of the test methods were capable only of detecting organic chemical contamination and could not distinguish specific contaminants. These tests found up to 68 parts per million (ppm) of organic contaminants in the Pleasant Plains water. One test which could characterize specific contaminants found 12 parts per billion (ppb) of toluene and 30 ppb of styrene in one well.[38]

At the time of the tests the only state or federal standard regarding organic chemicals in drinking water was a federal standard on organics removed by the carbon chloroform extract (CCE) method. This standard recommended that water with more than 0.7 milligrams of organic chemicals per liter extracted by the CCE method (equivalent to 0.7 ppm) be replaced with purer water if possible.[39] Only one of the wells tested by the CCE method exceeded this standard; it had a reading of 1.2 ppm extractable organics. Other wells sampled ranged from 0.1 ppm to 0.4 ppm.[40]

Protection of public health--State and local health authorities took action as the test results came in.

To provide Pleasant Plains residents with an interim water supply the New Jersey National Guard and the Ocean County Defense stationed seven tanker trucks throughout the community in June 1974, and the Toms River Water Company put spigots on three of its fire hydrants in the area so that residents could obtain water from them. In addition, many residents of the area purchased bottled water for drinking and cooking purposes.[41]

In June, Township officials recieved an anonymous tip that some drums of waste might still be buried on the Reich farm. A search turned up 51 drums and a quantity of chemical wastes. Union Carbide removed the drums and approximately 1,000 cubic yards of soil and disposed of them in a secure landfill. In addition, another 37 drums were discovered stored on two trucks belonging to Fernicola that were parked about four miles from the Reich farm. Union Carbide removed and disposed of these drums as well.[42]

On July 8, 1974, the New Jersey Department of Environmental Protection (DEP) recommended that water from a municipal water system be made available to Pleasant Plains residents as soon as possible, and that until such a system was available, that residents filter their well water through activated carbon.[43]

Finally, on July 30, the DEP determined that it was "unequivocally apparent that the groundwater [in Pleasant Plains] is containminated with organic chemicals" and directed the Township government to prohibit the use of water for drinking purposes from wells along specified streets in Dover Township.[44] DEP ordered this ban not because any specific standard regarding purity of drinking water had been violated, but because the well water had a strong chemical taste and odor, because tests indicated that the water was contaminated with uncharacterized organic chemicals, and because it was known that hazardous chemical wastes had been dumped on the Reich farm, which is within the contaminated area. The finding that triggered DEP's action was apparently the discovery in late July of toluene and styrene in one of the Pleasant Plains wells. At the time it ordered the ban, DEP also wrote to the New Jersey Board of Public Utility Commissioners, recommending that the Board order the nearest piped water system, the Toms River Water Company, to extend its lines into the contaminated area.[45]

In response to the DEP directive of July 30, the Township Board of Health on September 16, 1974 ordered residents in the contaminated area to seal their wells at their own expense, prohibited the use of water from those wells for any purpose, and prohibited the construction of new wells.[46] The Ordinance affected wells along the streets specified in the DEP directive, and, in addition wells along three other streets.[47] Altogether, 148 wells were ordered sealed.[48] Many residents simply ignored the order and failed to seal their wells until the Township began a serious effort to enforce the Order in early 1976.[49] By late Spring 1977, all 148 affected wells had been sealed.[50]

To provide residents of Pleasant Plains with a permanent supply of potable water, the Township petitioned the State Board of Public Utility Commissioners (PUC) to order the Toms River Water Company to extend its lines to the Pleasant Plains area at its own expense. The Board ordered the company to do so on September 12, 1974. Residents, however, were required to pay for the cost of hooking up to the water mains once they were extended into the area,[51] estimated to cost $100 per household.[52]

On December 31, 1974, DEP issued its final report on the underground pollution in Dover Township.[53] In this report, DEP designated a portion of the Township approximately one square mile in area Zone I, and concluded that this zone had contaminated groundwater. Zone I, which corresponds to the area in which wells were ordered to be sealed by the Board of Health, has at its center the Reich farm, the likely source of the groundwater contamination (see Figure B-2). In accordance with the Board of Health's order, no new wells were allowed to be constructed in Zone I. DEP designated a second portion of the township comprising approximately three square miles as Zone II. It concluded that groundwater quality in this zone was questionable, and recommended that testing for contamination continue in this area. In addition, DEP recommended that new wells in Zone II be drilled deeper, down to the relatively uncontaminated Kirkwood Aquifer. The rest of the Pleasant Plains area was designated Zone III; DEP concluded that the groundwater in this zone was not contaminated, and was not likely to become contaminated in the future.

The report considered two possible sources of the groundwater contamination in addition to the Reich farm: the Dover Township landfill and the Toms River Chemical Company, located in Zones II and III respectively. DEP determined that the groundwater contamination could not be traced to either of these sources.

Discovery of further groundwater contamination; response--In March 1976, several residents along two streets in the southeast corner of the Zone II section of Dover Township complained to the Township Board of Health that their well water had a bad taste and odor, and petitioned the Board to make arrangements to have the municipal water system's mains extended to their area at no cost.[54] The Board of Health took samples from the residents' wells on March 10, 1976; tests revealed that the water was contaminated with phenol.[55] On March 15, 1976, the Township Board of Health and the county Health Department advised residents in the affected section of Zone II not to drink or cook with their well water.[56]

Testing of well water from the area continued. On August 11, 1976, DEP announced that carbon tetrachloride had been found in four of ten samples taken, in levels ranging from 0.2 to 11.0 ppb.[57] Noting that carbon tetrachloride was a suspected carcinogen, DEP directed that thirteen private wells along the two streets affected be condemned and sealed, and recommended that piped water be provided to the affected area.[58]

On November 10, 1976, the Board of Public Utility Commissioners ordered the Toms River Water Company to extend their lines to the two affected streets. The thirteen households along the streets were required to pay $400 each, or $5,200 total, toward the cost of the extension, and in addition, approximately $100 each for hookup. Dover Township absorbed the $20,000 cost of resurfacing the streets once the lines had been laid. The Toms River Water Company bore the remaining cost of approximately $17,000. Altogether, the extension of the lines to the affected area in Zone II cost roughly $43,500.[59]

Enforcement action and private suits in response to groundwater contamination--

Pleasant Plains residents against Union Carbide--In October 1974 seven Pleasant Plains residents, subsequently joined by 52 additional residents in May 1976, filed a class action suit against Union Carbide,[60] alleging that the company was responsible for the contaminated groundwater, and seeking compensation for the loss of their wells. In December 1977, the case was settled in a consent order.[61] Union Carbide, without admitting that it was responsible for any of the groundwater contamination, established a fund of $101,000 to compensate the residents. Under the settlement, each person who owned property within the area subject to the Board of Health's first condemnation order (Zone I) or any person who was required to seal his well as a result of that ordinance, would receive $1,000 from the fund in exchange for releasing Union Carbide from any additional claims in connection with the groundwater contamination.[62] Of the 152 persons eligible, 140 have signed releases and received compensation under this settlement thus far.[63]

State of New Jersey against Union Carbide and Fernicola--On December 18, 1975, the Attorney General of New Jersey filed suit against the Union Carbide Corporation and Nicholas Fernicola. In its complaint, the state charged Union Carbide with creating a public nuisance and charged both the company and Fernicola with violating state water pollution laws.[64] The state requested the court to direct Union

Carbide to abate the contamination of groundwater, and pay compensatory and punitive damages, and to impose penalties on the company and Fernicola for violating the water pollution law.

A consent order was agreed to on April 21, 1977, under which Union Carbide agreed to pay the state up to $60,000 to defray any costs it might incur after that date for investigating, sampling, or purifying the groundwater in Dover Township.[65] As the state incurs costs for these purposes, it bills Union Carbide for reimbursement. So far the state has received $6,341.50 under the terms of the settlement.[66] If by 1982 the state has billed Union Carbide for less than $30,000, Union Carbide will pay the state a lump sum of $30,000, ending its obligations under the settlement. If Union Carbide has been billed for more than $30,000, it will pay the state the difference between what it has been billed for and $60,000. In exchange for these payments, the state released Union Carbide from all further claims in connection with the groundwater contamination.

The state settled its suit against Fernicola on June 1, 1977 in return for a payment of $100.[67]

Costs

Private Costs of Waste Disposal--

Actual cost of illegal disposal--Union Carbide paid Fernicola $3.50 per drum to haul away and dispose of approximately 6,000 drums of waste, or roughly $21,000 altogether. The Dover Township landfill, where Fernicola apparently disposed of some of the waste, does not charge for the use of its facilities. Fernicola paid the Reichs $40 per month for the use of the portion of their farm where he dumped most of the wastes; however, the Reichs did not know that Fernicola planned to dispose of waste on their property when they agreed to lease part of their farm to him.[68]

Comparative cost of proper disposal--Proper disposal of the wastes would have cost somewhat more than Fernicola charged. Fernicola himself said in a 1974 interview that the price he charged was "at least a quarter to a half a dollar less" than what other haulers of chemical waste were charging.[69]

Alternative means of disposal available to Union Carbide in 1971 included an incinerator and at least one approved landfill. The incinerator, operated by Rollins Environmental Services in Logan Township, New Jersey, would have charged $3.85 to $5.50 per drum for incineration and another $1 to $2 for transportation to the incinerator.[70] Perhaps the most logical alternative available to Union Carbide in 1971 for proper disposal of chemical wastes was the Kin-Buc landfill in Scotch Plains, New Jersey. Although problems later surfaced at Kin-Buc, at the time it was considered to be the state of the art, and Union Carbide's Bound Brook plant used it regularly.[71]

Social Costs of Illegal Disposal--

Natural resource damage--As a result of the improper dumping of chemical wastes, the Cohansey aquifer and the upper portion of the Kirkwood aquifer have become contaminated with organic chemicals. The state of New Jersey has determined that the aquifers cannot be purified.[72]

Property damage--The Township Board of Health ordered 148 domestic wells in Zone I and another 13 wells in Zone II sealed at their owners' expense; this was estimated to cost $300 per well,[73] or $45,300 altogether. Eventually residents with contaminated wells were able to connect up to the municipal water supply, for which they had to pay an average connection fee of $100[74] each or $15,100 in total. In the interim, they had to pay for bottled water or bear the inconvenience of going to tank trucks or spigots stationed throughout the affected area to pick up water.

Extending the municipal water system to Pleasant Plains cost the Toms River Water Company roughtly $180,000.[75] Since the Company is a regulated public utility, it can be assumed that most if not all of this cost was passed on to its ratepayers. Dover Township paid approximately $92,000 to resurface the roads that had been torn up to lay the water mains.[76] In addition, the thirteen households in Zone II had to pay $400 each or $5,200 in total, for the extension of the water system to their area.[77]

New wells in Zone II had to be drilled deeper to the Kirkwood Aquifer, increasing the cost of constructing a well. As of 1976, approximately 20 households in Zone II had drilled deeper wells at an estimated cost of $2,300 per well.[78] Buying water from the municipal system costs Pleasant Plains residents approximately $30 per year more than it does to operate a private well; the cost differential is higher for houses with swimming pools or large lawns and gardens.[79] For some, relying on water from the municipal system imposes an unquantifiable aesthetic cost as well: many residents in the affected area find that the piped water has a funny taste compared to well water.[80]

Residence-related damage was suffered by the five tenants evicted by their landlord in early 1974 when it was discovered that water from the property's well was contaminated.

Property values in Pleasant Plains declined when the groundwater contamination became known; one estimate puts the decline at 20 to 25%.[81]

Acute and Latent Health Effects--In June 1974, the Disease Control Section of the Ocean County Health Department conducted an "illness survey" in Pleasant Plains to investigate any possible health effects due to the contaminated groundwater. Twenty-three families comprising forty-eight persons altogether were interviewed. Tests had indicated that wells for ten of these families were contaminated and that another four were uncontaminated. No test results were available for nine of the wells. Fifteen of the twenty families reported illnesses of some sort involving kidneys, stomach, liver, or gall bladder, and eight reported no illness. Illness was reported both by families with contaminated and uncontaminated wells, as well as those with wells for which no test data were available. As a result, the surveys made no correlation between the use of contaminated well water and illness.[82] It should be noted that this survey appears to have been a rather casual investigation and not a rigorous epidemiological survey.

Children of one family were reported to have body rashes that disappeared after they stopped using well water.[83] Stomach problems were also reported.[84] Neither of these reports have been medically documented.

The full range of possible latent health effects due to the groundwater contamination in Dover Township cannot be determined because not all the chemicals present in the groundwater were characterized, and the duration of exposure to contaminated groundwater is unknown. Most of the testing simply detected organic chemical pollution without specifying what substances were present.

Some contaminants were identified, however. Styrene, phenol, carbon tetrachloride, and toluene were detected in various wells. Phenol is mutagenic, promotes tumor growth, and produces reproductive effects.[85] Carbon tetrachloride is carcinogenic, is suspected of being mutagenic, and is toxic to the liver and kidneys. The National Academy of Science's report, *Drinking Water and Health*, found no data available on the mutagenicity, carcinogenicity, or teratogenicity of styrene or toluene.[86]

Enforcement and litigation costs--No estimate has been made of what the Dover Township waste dumping and groundwater pollution has cost the government. A 1976 report prepared for EPA estimated that as of May 1975, the incident had cost local, state and federal government $33,600 for supervising the waste cleanup, obtaining and testing water samples, and drafting the order closing down the Pleasant Plains wells.[87] However, this estimate does not cover all the costs to government over this period. For instance, the only costs to the state covered by the estimate are for testing water; general administrative expenses borne by the Department of Environmental Protection and the Board of Public Utility Commissioners are ignored. In addition, the estimate does not cover costs incurred after May 1975, which would include well monitoring and the costs of the action that the state brought against Union Carbide and Fernicola.

Full information is not available on litigation costs. The plaintiffs' attorneys in the class action suit against Union Carbide received $50,000 in fees under the settlement reached in that case.[88] There is no information on the amount Union Carbide or the Reichs spent on legal services.

Clean-up costs--Dover Township spent an estimated $10,000 to inspect and supervise the removal of the waste dumped at the Reich farm.[89] Union Carbide bore the Reich farm clean-up costs. The company refuses to disclose how much it spent on the cleanup. Ghassemi estimates that Union Carbide spent $15,750 to remove 4,500 drums from the Reich farm in 1972,[90] but he probably has underestimated the cost substantially. Ghassemi derived his estimate by assuming that the cost of removing and disposing of the drums from the site was $3.50 per barrel, the same amount that Union Carbide originally paid Fernicola to haul the wastes from its plant. The cleanup must have cost far more than $3.50 per drum, however since the scattered barrels had to be collected and their contents identified. Furthermore, Union Carbide shipped approximately 2,500 drums of waste to its plant in Marietta, Ohio, which would have made the disposal more expensive.

A roughly similar clean-up operation at the Valley of the Drums in Kentucky will cost an estimated $50 per drum in 1980.[91] Since waste disposal and the price level in general were lower in 1971, this figure cannot be applied to the Dover Township cleanup, but it does provide a reference point against which to judge 1971 costs.

Cost Redistribution--

The Reichs are reported to have received from Union Carbide $10,000 and reimbursement for the cost of drilling a new well as compensation for damages done to their property as a result of the dumping of the waste. One hundred forty of the 152 eligible Pleasant Plains residents have received from Union Carbide $1,000, or $140,000 in total, as compensation for the loss of their wells. The State of New Jersey will receive from Union Carbide up to $60,000 to compensate it for costs connected with the groundwater contamination that it incurs after April 21, 1977.

Footnotes

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2. Steven H. Corwin, New Jersey State Department of Environmental Protection, *Final Report--Delineation of Extent of Groundwater Contamination, Pleasant Plains Section of Dover Township, Ocean County, New Jersey* (December 31, 1974), p. 4.

3. Union Carbide Corporation, *Annual Report for 1971*.

4. Interview with Lawrence Stanley, Deputy Attorney General for the State of New Jersey (May 6, 1980).

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6. M. Ghassemi, *Analysis of a land disposal incident involving hazardous waste materials, Dover Township, New Jersey* (EPA Contract No. 6F-01-2956, Task Order 6F-01-3187, May 1976), p. 73.

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9. *Supra*, note 6, pp. 80-83.

10. New Jersey v. Union Carbide et al., No. C-1597-75 (Sup. Ct. Ocean Cty.), Pretrial memorandum of Union Carbide.

11. *Ibid*.

12. *Supra*, note 6, pp. 9-12; interview with Mr. Thompson, Director of Public Works, Dover Township (May 27, 1980).

13. *Supra*, note 6, pp. 9, 12.

14. *Ibid*., p. 12.

15. *Ibid*.

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18. Ibid.

19. Ibid.

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21. New Jersey Administrative Code 7:26-1.1 et seq. (1970).

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28. Supra, note 5.

29. Supra, note 23.

30. Supra, note 27.

31. N.J.S.A. 26:2C-19.

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33. Supra, note 6, p. 19.

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35. Supra, note 6, p. 23.

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44. Letter from John C. Wilford, Chief, Bureau of Potable Water, DEP, to the Mayor of Dover Township (July 30, 1974).

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82. *Supra*, note 6, p. 51.

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LOCAL OPPOSITION CLOSES APPROVED HAZARDOUS WASTE MANAGEMENT FACILITY IN WILSONVILLE, ILLINOIS

Introduction

Local opposition forced SCA Services, Inc. to close its hazardous waste disposal facility in Wilsonville, Illinois after it had been in operation for less than a year, even though the facility had been permitted by the Illinois Environmental Protection Agency (IEPA) and approved by the Environmental Protection Agency (EPA). The Village of Wilsonville together with Macoupin County, Illinois and the Illinois Attorney General successfully argued that SCA's facility constituted a public nuisance and that it posed a substantial threat of environmental contamination in the future, winning an injunction that not only shut down the facility, but ordered complete exhumation of the wastes and site reclaimation. SCA lost a 1980 appeal to the Illinois Appellate Court, and on May 22, 1981 this decision was affirmed by the Illinois Supreme Court. SCA may seek _certiori_ by the U.S. Supreme Court. SCA's experience illustrates the power of local opposition in preventing the continued operation of a permitted hazardous waste facility.

Background Information

The Location--

The hazardous waste management facility in Wilsonville, Illinois came into being when a manager of IEPA's Division of Land Pollution Control recognized the need for proper hazardous waste disposal facilities. He left IEPA and in 1974 chartered Earthline, Inc., a private engineering consulting firm, to establish a hazardous waste landfill.[1]

The Wilsonville facility was the first waste disposal site developed by Earthline. The Village of Wilsonville, population 700, is located in southwestern Illinois approximately fifty miles northeast of the St. Louis metropolitan area. It is a largely rural community with an economy based on agriculture and coal mining. Many of the village's residents commute to jobs in St. Louis due to a decline in coal mining in the Wilsonville area.

Earthline chose Wilsonville for its landfill because it is close to a major industrial area (St. Louis), has what it believed to be favorable hydrogeological characteristics, and is relatively undeveloped.

The Wilsonville site is primarily a landfill, but also has facilities for short-term storage of recyclable waste, and for land-farming waste. The waste disposal site encompasses approximately 130 acres, 90 of which are located within the boundaries of Wilsonville, and was projected to have a twenty-year land-fill capacity.[2]

To the north the site borders on residential property; to the south, east, and west it borders on agricultural or undeveloped land. The existing waste burial trenches are located one-quarter of a mile from the northern and most populated border. The entrance to the site is on the main street of Wilsonville, so trucks carrying waste to the landfill had to pass through the Village.

The surface of the site consists of a ten-foot layer of loess (wind-blown silt and clay) and is underlain by 40 to 65 feet of dense glacial till. Within the till is a thin layer of sand with a thickness of from a few inches to two feet, located 30 to 40 feet below the surface. Disposal trenches were dug into the loess and extended no more than one to two feet into the till layer, so that there would be at least 10 feet of till between the bottom of the trenches and the sand layer.[3] The trenches apparently were not lined with any material that would have increased natural impermeability of the soil.

The landfill is situated above a deep shaft coal mine abandoned in 1954. The land was not reclaimed after the mine close, and piles of coal, shale, and clay mine tailings cover approximately forty acres of the site. Groundwater near the mine site has become highly acidic from oxidation of pyrites in the tailings.[4]

The Earthline landfill was designed to reclaim the mine site in the course of its operation as a waste disposal facility. Excess soil from the disposal trenches was to be used to cover the surface of the tailings pile with the goal of retarding the flow of water into the tailings pile, thereby reducing the acid mine draining.

Development and Operation of the Landfill--

Around December 1975 Earthline leased the property from its owner, with the understanding that it would develop a hazardous waste management facility there.[5] On February 11, 1976, Earthline applied to IEPA for a permit to develop a hazardous waste facility on the site.[6] The Illinois Environmental Protection Act gives IEPA authority to review and permit hazardous waste landfill operations and preempts any local regulatory control over the siting of hazardous waste facilities.[7] The IEPA permit process for siting a hazardous waste facility involves three steps: 1) issuing a permit for site development, 2) inspection of the completed facility by IEPA personnel, and 3) issuing an operational permit.

While IEPA reviewed its application for a site development permit, Earthline made an attempt to inform the citizens of Wilsonville of the planned facility and secure their support for it.

In February 1976 Earthline notified local officials and neighboring landowners by letter that Earthline was planning to build the facility.[8] In its letter Earthline stated that the facility would "assist in conserving our precious resources and protecting our environment." Earthline did not explicitly state that its facility would dispose of hazardous wastes but rather euphemistically termed "the recovery, treatment, storage, and containment of industrial residues."[9] Earthline also implicitly promised that the site would provide jobs for Wilsonville residents and that the facility would eventually reclaim the mine wastes on the site.

According to the Village of Wilsonville, its attorney responded to Earthline's letter on March 3, 1976. He wrote that the village supported establishing industry on the property, but he was concerned that the operation Earthline described in its letter might include a landfill, and added "of course, the Village would object most strongly to [this]."[10]

IEPA granted Earthline a development permit in July 1976, approving the site for the following processes for treatment and storage of wastes: 1) hazardous waste landfilling, 2) acid-alkaline neutralization, 3) chemical fixation, and 4) short-term storage of recyclables.[11]

Initial development of the Wilsonville site was completed by September of 1976.[12] After inspecting the facility, IEPA granted Earthline an operational permit for the site on September 23, 1976.[13] Disposal operations began on November 15, 1976;[14] on the same day Earthline held an open house at the facility to inform local residents about the facility. Earthline also met with the Wilsonville Village Board at this time. The extent to which Earthline made clear at these meetings that its facility would dispose of hazardous waste is disputed.

SCA Services, Inc. purchased Earthline in October 1976. SCA, located in Boston, Massachusetts, is the third largest waste service company in the United States with over $180 million total corporate revenues for 1978.[15]

The site accepted all types of hazardous and industrial wastes with the exception of radioactive wastes, strong acids, and explosives. In April 1977 Earthline had IEPA permits for the legal disposal of 185 types of hazardous wastes, including PCBs.[16]

Earthline's primary market was the St. Louis metropolitan area; however, it also received wastes from Indiana, New Jersey, and Missouri.[17] The companies that contracted with Earthline for waste disposal include Velsicol, American Cyanamid, Monstanto, Dupont, Ford, General Motors, McDonald Douglas, Uniroyal and Western Electric.[18]

Residents of Wilsonville voiced only minor complaints about the facility during its first four months of operation. There were some complaints of odors from the facility; that the facility did not hire enough local residents; that trucks carrying wastes to the site damaged local streets; and that a few hazardous chemicals were spilled. However, there was no organized opposition to the site until April 1977.[19]

PCB Disposal Arouses Local Opposition--

In early April 1977, the residents of Wilsonville learned that EPA had chosen Wilsonville as the burial site for soil contaminated with PCBs that had been illegally dumped along a creek in Dittmer, Missouri.[20] Wilsonville was the closest landfill suitable for the disposal of PCBs. IEPA issued an emergency permit to Earthline to accept the wastes on approximately April 8, 1977.[21] Up to this point, most Wilsonville residents were apparently unaware that the facility accepted hazardous waste. The citizens of Wilsonville, alarmed by news reports stressing the toxicity of PCBs, became violently opposed to the disposal and threatened to forcibly close the site themselves if the courts would not do so. On Friday, April 15, 1977, Wilsonville's state senator and the manager of IEPA's hazardous waste subdivision held a meeting to reassure residents of the safety of the operation.[22] However, residents' fears intensified and by Sunday, April 17, 1977, residents had armed themselves and were ready to close down the facility by force.

In response to local sentiment, the Village of Wilsonville on April 18, 1977 filed suit agains Earthline in Macoupin County Circuit Court to enjoin it from accepting the PCB-contaminated soil.[23] The court that same day granted a temporary restraining order enjoining Earthline from hauling PCBs through Wilsonville and disposing of them on the site.[24] In April Earthline successfully petitioned the Appellate Court to dissolve the restraining order[25] and by May 1, 1977 the disposal facility had reopened.[26]

On April 29, 1977, Macoupin County, the county in which the facility is located, joined forces with the Village of Wilsonville and filed suit to prevent Earthline from accepting the PCBs.[27] The Macoupin County Farm Bureau was granted leave to intervene in the case May 9, 1977 and shortly thereafter filed a complaint asking the court to enjoin Earthline from accepting not only the PCB-contaminated soil but all other toxic wastes that had been deposited on the site up to that point.[28] The Village of Wilsonville and Macoupin County amended their complaints in mid-May to similarly seek an end to the disposal of all toxic wastes at the site, not just PCBs, and to compel Earthline to remove wastes already deposited there.

Earthline petitioned the court to add the U.S. EPA as necessary defendants in the suits, but it declined to do so. EPA then obtained leave to enter the case as an amicus curiae.[29]

On May 26, 1977 the Illinois Attorney General filed a complaint against Earthline, charging it with violating state water pollution laws and asking that the site be closed and the wastes deposited there be removed.[30] Up to this point, the Attorney General had been representing IEPA in court in the case. IEPA had approved the site and was in favor of Earthline's continued operation, so the Attorney General's suit produced a split within the state government with respect to the case. These three complaints against Earthline were consolidated for trial on June 2, 1977.[31]

The Governor of Illinois became involved in the controversy by instituting a 45-day moratorium on the issuance of new hazardous waste disposal permits on May 30, 1977.[32] Under the Illinois Environmental Protection Act, the operator of a hazardous waste landfill is required to obtain a separate supplementary permit for each shipment of waste buried in the landfill. Since at the time of the moratorium Earthline held over 150 permits that were still in effect, the moratorium had no immediate impact on the facility's operations, beyond intensifying the controversy. The Mayor of Wilsonville, however, acting on the Governor's moratorium, stopped five trucks from entering the site.[33]

Litigation: Allegations and Defenses--

The suits brought against Earthline by the Village of Wilsonville, Macoupin County and the Illinois Attorney General charged that Earthline was maintaining a present and future public and private nuisance through operation of its facility and that Earthline was violating the water, air and land pollution laws of Illinois.

Present nuisance--The plaintiffs alleged that operation of the facility created a present nuisance because hazardous wastes were hauled through the village and because the site emitted dust and odors. Local residents testified at the trial that such hazardous waste as PCBs were transported to the landfill in unsealed barrels on open trucks, and that waste leaked as a result. The problem was magnified by the fact that the only access to the site was from the main street of Wilsonville. Residents of Wilsonville also testified the facility emitted unpleasant odors and that emissions from the dump had caused health effects ranging from shortness of breath and burning eyes to general sickness and nausea.

To counter these charges, Earthline testified that it planned to construct a $400,000 road around the outskirts of the Village that would remedy the problem of access to the site.[34] Earthline testified that it had not yet started to construct this alternative route because it wanted to be assured of the economic feasibility of such a project. Earthline held that odors and possible related health effects were due not to emissions from its faciliy, but to area residents burning trash in open barrels and dumping sewage in a nearby trench.

Future nuisance--The plaintiffs charged that the landfill presented a future nuisance because the site was unsuitable for hazardous waste disposal and would be unable to contain the wastes in the future, thereby causing environmental contamination.[35] The controversy over the suitability of the site centered on the permeability of its soil and the possibility of subsidence of land over the abandoned mine.

If mine subsidence were to occur, the plaintiffs charged, the disposal trenches could develop cracks that would allow leachate to seep out and contaminate the groundwater.[36]

Expert witnesses for the plaintiffs testified that subsidence had occurred in the mine underlying the site, and that cracks resulting from subsidence could extend all the way to the surface and breach the disposal trenches.[37]

Earthline's witnesses responded that the likelihood of subsidence was negligible and that any subsidence cracks that might develop would not extend to the bottoms of the trenches. However, the plaintiffs were able to challenge Earthline's witnesses with evidence that subsidence cracks extending to the surface had in fact developed in the area surrounding the landfill.[38]

The second major area of dispute over the site's suitability concerned soil permeability. The permeability tests originally taken at the Wilsonville site during the IEPA permit procedures showed that the site met the IEPA standards, which require that waste must be contained within ten feet of the disposal site for five hundred years.[39] Evidence presented during the trial claimed that the tests were in error and that the site is actually 100 to 10,000 times more permeable than what the standards allow, with a containment time possibly as low as 50 years.[40]

EPA and the Illinois State Geological Survey testified in Earthline's defense that after extensive monitoring of the disposal facility, they had determined that it was safe, met all existing criteria for a chemical waste landfill, including permeability requirements, and showed no signs of having contaminated the surrounding soil or groundwater.[41]

Circuit Court Decision--

On August 28, 1978, after 16 months of litigation the court ruled in favor of Wilsonville and its allies in the litigation and ordered the disposal facility closed and all wastes buried there exhumed.[42]

The court had to choose between the conflicting testimony of two sets of expert witnesses and in the end sided with the plaintiff's witnesses. In general, the court found that the Earthline site had caused air, water, and soil pollution and would continue to do so in the future. It found that transportation of wastes to the site posed an imminent hazard to the public, that there was a "strong likelihood" that wastes would escape from the landfill within twenty years through subsidence cracks, and that toxic substances from the site have traveled and/or will travel to adjoining lands. The court also found that Earthline was deceptive and misled Wilsonville as to the purpose of the site and the materials to be buried there.[43]

Appeals--

Earthline appealed the decision to the Illinois Appellate Court and asked the court to stay the Circuit Court's order. On September 14, 1978, the Appellate Court denied Earthline permission to remain open during the appeals process,[44] but granted it a stay on exhuming the wastes pending the outcome of its appeal.

On September 21, 1979, the Appellate Court of Illinois upheld the Circuit Court's decision to close the site, and again ordered the exhumation of all wastes.[45] It stayed this order, however, pending appeal to the Illinois Supreme Court.

In its appeal, Earthline had argued, among other things, that IEPA and the Illinois Pollution Control Board, and not the Circuit Court had jurisdiction over the case, or, alternatively that the Court should have deferred to those two agencies. The Appellate Court, however, found that the Circuit Court did have jurisdiction over the case; the fact the IEPA had issued it a permit to operate as a hazardous waste landfill did not prevent the Circuit Court from ruling on whether or not the landfill created a public nuisance.[46]

Earthline had also argued on appeal that the "manifest weight of the evidence" did not support the Circuit Court's finding that the landfill constituted a present and future nuisance. The Appellate Court recognized that the expert testimony offered by both sides conflicted, but held that the plaintiffs had shown that release of the substances in the landfill would have catastrophic consequences. Even if the chances that a release in fact would occur were uncertain and even if the threat of releases might be remote in time, the Appellate Court found that the consequences of a release were so serious as to justify the Circuit Court's injunction against the site.[47]

Earthline had further argued that the Circuit Court should have balanced the benefits of its landfill against any possible harm that might result from it. The Appellate Court found that balancing was not required, again because of the extreme seriousness of possible harm from the site.[48]

In October 1979, Earthline petitioned the Illinois Supreme Court for leave to appeal the Appellate Court's decision to close the site.[49] The Supreme Court denied Earthline's petition. On May 6, 1980, Earthline petitioned the Supreme Court once again and on May 15, 1980, the court granted Earthline leave to appeal.[50]

On May 22, 1981 the Supreme Court affirmed the lower court rulling and ordered SCA Services to remove all wastes and contaminated soil buried on-site and to restore and reclaim the site.[51]

Epilogue: Problems of Public Acceptance--

The Wilsonville case illustrates several problems involved in siting a hazardous waste facility. Along with questions of the site's geological suitability, public acceptance of and the degree of local control over the site also played a critical role in the controversy.

Because the IEPA preempts local authority in siting hazardous waste facilities, the Village of Wilsonville had no control over the siting of the Earthline landfill. The siting process was carried out solely between the facility sponsor, Earthline, and the Illinois Environmental Protection Agency. During both the Circuit Court and Appellate Court trials, local officials expressed dissatisfaction over not having been given a substantive role in the siting process.[52] The Illinois Pollution Control Board has authority to conduct public hearings on siting of hazardous waste facilities, but hearings were never conducted on the Earthline landfill.

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Local citizens say they did not petition the Board for hearings because they were unaware of the threat that the facility presented, and were unaware that such review measures were available.[53]

Earthline attempted to secure support from local residents prior to the opening of the facility through an open house and meetings with local elected officials. However, residents testified that while they were told that the facility was going to "recycle industrial residues," they did not understand that it involved dangerous chemicals or the potential for environmental contamination.[54] Earthline was not legally required to involve the residents in the siting procedure, but doing so would have allowed the residents to express concern over the transport of hazardous wastes through the Village, or the proximity of the burial trenches to residential property;[55] and perhaps would have led to an amicable resolution of these problems.

Local officials also claimed Earthline had promised to provide jobs for local residents in order to gain public acceptance. Due to the decline of coal mining in the area, this perceived promise was a major factor in the Village's initial non-resistance to the facility. Earthline, however, failed to employ local citizens, so the Village had no economic interest in the continued operation of the facility.

Costs

Private Costs of Siting a Hazardous Waste Disposal Facility--

SCA Disposal Services has hesitated to provide cost figures of its investment in the Wilsonville site, primarily because the company may yet seek *certiorari* by the U.S. Supreme Court. However, SCA admits that its expenditures have been substantial. The costs of litigation alone have been three-and-one-half times as much as it originally invested to develop the site.[56]

Without the cost figures from SCA, the following discussion of private costs is limited to the "types" of costs incurred by the company in developing the Wilsonville site.

Cost of site selection--Earthline originally examined several alternative locations for a landfill before choosing the Wilsonville site on the basis of hydrogeologic suitability in a relatively undeveloped area. This phase included the costs of locating various alternative locations, initial testing for suitability as a landfill, and finally contracting with the owner of the property under a financial agreement to develop the site.[57]

Cost of securing IEPA permits--The procedure for developing a hazardous waste landfill in Illinois requires extensive testing of the hydrological and geological characteristics of the site in order to get IEPA permit approval once the site is selected. SCA/Earthline spent nine months securing development and operational permits from the IEPA for the Wilsonville site.[58] The first step, securing a development permit, included extensive testing of the hydrogeological characteristics of the site, designing the facility according to specifications required under the Illinois Environmental Protection Act for hazardous waste landfills, as well as submitting extensive technical designs for the proposed processes of waste treatment, disposal, and storage.[59] The second step, once the development permit was granted by IEPA, included the costs of constructing the landfill according to the IEPA specifications, and submittal of an application upon completion of construction to the IEPA for an operational permit. The IEPA spent approximately four months reviewing the site for an operational permit, granting final approval to the site in November of 1977.[60] When disposal operations finally began, SCA had invested a considerable amount of time, effort, and expense to secure government approval.

Cost of securing public support--SCA's costs in securing public support of the Wilsonville facility are not available. However, these costs presumably were considerably lower than SCA's expenditures in securing IEPA approval because Illinois law preempts local authority in siting hazardous waste facilities.[61] SCA was not legally required to seek local government approval in choosing to located the landfill in Wilsonville, but it tried to establish "good public relations" with the local residents through notification letters concerning the proposed development and an open house. Presumably, these costs were minimal.

Social Costs of Siting a Hazardous Waste Disposal Facility--

The cost of having the site (regional)--

Natural resource damage--Conflicting testimonies were presented during both the Circuit and Appellate Court trials concerning the extent of natural resource damage from the Wilsonville site. The major area of dispute concerned the potential for environmental contamination that could possibly occur through land subsidence which could potentially rupture the disposal trenches.[62] At the present time, however, instances of subsidence, chemical migration, or groundwater contamination have not been reported.

Property damage--Local residents have complained that the facility has caused considerable property devaluation, especially to the residences located along the borders of the

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facility. The values of the homes range from $15,000 to $30,000, and would be rendered valueless if the wastes migrated from the site.[63] However at the current time residential property has not been contaminated.

Acute and latent health effects--At the present time the site does not pose an immediate health threat to local residents. Fifteen citizens stated that they experienced nausea, headaches, and general sickness from the odors emanating from the site; however, extensive EPA monitoring has not found any environmental contamination.[64] Again, the health danger that the site imposes is a potential future danger of chemical migration from the site. Both the EPA and the IEPA feel that the site does not pose a threat to public health in the future because the site is fully contained.[65]

Cost of not having the site--Closing the Wilsonville site will also impose indirect costs. One such cost will be the loss of an approved hazardous waste facility, one of the few which EPA has found suitable for the disposal of PCBs. Hazardous waste generators in the area once served by the Wilsonville site may have to pay more and haul their wastes farther to find another suitable disposal site.

Another indirect cost is the chilling effect the court's order to close and exhume the site might have on other firms considering investing in hazardous waste disposal. Firms might conclude from the Wilsonville experience that official approval of a hazardous waste disposal facility offers no protection against disgruntled neighbors who want to close the facility. The resulting uncertainty might lead some firms to decide against investing in hazardous waste disposal facilities. By reducing the supply of disposal facilities, this would tend to make hazardous waste disposal more expensive. Firms that chose to operate hazardous waste facilities in spite of the uncertainty might raise their fees to insure themselves against the possibility of an adverse judgment.

On the other hand, the Wilsonville site is in some ways unique. For example, it is constructed on an abandoned coal mine and is fairly close to an inhabited area. These factors may keep the Wilsonville case from setting a precedent with wide-ranging applicability, thus reducing its chilling effect. The Wilsonville case could also have the beneficial side effect of inducing operators of hazardous waste facilities to take even more care in the siting of their facilities.

Cost of Removing Wastes from the Site--

SCA will bear the direct cost of the Illinois Supreme Court's decision to uphold the lower court's order to permanently close and exhume all wastes from the Wilsonville landfill.[66]

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A rough estimate of the total cost of exhuming the Wilsonville site is approximately $2,000,000.[67] SCA was required to post a $2,000,000 bond pending further appeal. The two million dollar figure is based upon an affidavit SCA presented to the appellate court during its August 1978 request for a stay to remain operative during the appeals process.[68] The affidavit stated that the cost of exhuming wastes buried during the anticipated nine month appeal process would be $737,000 based on 1978 labor and equipment costs.[69]

Since the site had been operative for a year-and-a-half at the time of SCA's request and contained approximately two-and-one-half times the amount of wastes listed in the affidavit, approximately two million dollars may potentially be the cost of exhuming the entire site.[70] However, an attorney for SCA pointed out that this figure would not include transportation fees, or disposal charges at an alternative site.[71]

SCA is also unsure of where it might dispose of the wastes from the Wilsonville landfill if higher court review forces exhumation. However, SCA's attorneys feel that the regulations promulgated under the Resource Conservation and Recovery Act (RCRA) will require new disposal measures, and possibly encourage the opening up of new disposal sites and thus enlarge SCA's alternative for disposal of any exhumed waste.[72]

Footnotes

1. U.S. EPA, Siting of Hazardous Waste Management Facilities and Public Opposition, (Report SW-809) November 1979, p. 305.

2. Ibid.

3. U.S. EPA, Technical Report on Earthline Corporation Landfill, Wilsonville Illinois, October 1977, p. 11.

4. Supra, note 1, p. 304.

5. Ibid.

6. Ibid.

7. Illinois Environmental Protection Act, (1977 Ill. Rev. Stats. Chap. 111-1/2. 1001, et seq.).

8. Supra, note 1, p. 305.

9. *Supra*, note 3. Copy of letter from Earthline Corporation, February 11, 1976.

10. Brief for Appellee, Village of Wilsonville v. Earthline Corporation, 33 Ill. App. 3rd, 396 N.E.2d 522 (4th Dist., 1979).

11. *Supra*, note 1, p. 305.

12. State of Illinois, Appellate Court, Consolidated Case No. 79-218, Wilsonville v. SCA, p. 5.

13. *Ibid.*, p. 5.

14. *Ibid.*, p. 6.

15. *Supra*, note 1, p. 305.

16. State of Illinois, County of Sangamen, Sworn Affidavit of Douglas Andrews, August 28, 1978.

17. *Ibid.*

18. *Ibid.*, Exhibit B (List of companies under contract with Earthline, 1978).

19. *Supra*, note 1, p. 306.

20. *Ibid.*

21. *Ibid.*, p. 307.

22. *Ibid.*

23. *Ibid.*

24. *Ibid.*

25. Conversation with Fred Prillaman, Attorney for SCA Services, May 1980.

26. *Ibid.*

27. Illinois Cir. Ct., Macoupin County, Macoupin County v SCA, original complaint filed May 1977.

28. Complaint of Macoupin County Farm Bureau, Village of Wilsonville et al. v. Earthline Corporation, No. 77-CH-10 (Macoupin Cty. Cir. Ct., May 1977).

29. *Supra*, note 1, p. 308.

30. State of Illinois, County of Macoupin, Complaint for Injunction, Illinois v. Earthline, William J. Scott, Attorney General, No. 77, 13.

31. *Ibid*., p. 4.

32. *Supra*, note 1, p. 308.

33. *Ibid*., p. 308.

34. State of Illinois, Appellate Court, Fourth District, Agency No. 29-218, Court Opinion, September 21, 1979.

35. *Supra*, note 30.

36. *Ibid*.

37. Village of Wilsonville et al. v. Earthline Corporation, 33 Ill. App. 3d 163, 396 N.E.2d 552 (4th Dist. 1979).

38. *Ibid*.

39. Illinois State Geological Survey, "Geological and Geochemical Considerations on Disposal of Industrial Chemicals at Wilsonville, Illinois, Staff Report, November 3, 1977. *See also*, Illinois Environmental Protection Act, (1977 Ill. Rev. Stats. Chapt. 111-1.2, 1001, *et seq*.).

40. U.S. EPA, Technical Report Earthline Corporation Landfill, October 1977, U.S. EPA, p. 3 (*see also* 42 Fed. Reg. 26574 May 24, 1977 [PCBs]).

41. Illinois Appellate Court, Village of Wilsonville v SCA, App. 3 Ill., December, 163, 396, N.E.2d 552.

42. Village of Wilsonville et al v. Earthline Corporation, No. 77-CH-10 (Macoupon County Cir. Ct. August 28, 1977).

43. *Ibid*.

44. Conversation with Fred Prillaman, Attorney for SCA, Springfield, Illinois, June 1980.

45. *Supra*, note 41.

46. *Ibid*.

47. *Ibid*.

48. *Ibid*.

49. Conversation with Anne Carr, Illinois Attorney General's Office, May 1980.

50. *Ibid*.

51. Village of Wilsonville v. SCA Services, Inc., Environmental Law Reporter, 11 ELR 20698, (Ill. Sup. Ct., May 22, 1981)

52. *Supra*, note 1, p.310

53. *Ibid*., p. 310.

54. *Ibid*., p. 312.

55. *Ibid*., p. 312.

56. Conversation with Stuart Dobbs, Attorney for SCA, Springfield, Illinois, May 1980.

57. *Supra*, note 1, p. 305.

58. *Ibid*., p. 307.

59. Illinois Environmental Protection Act, (1977 Ill. Rev. Stats., Chapt. 111-1.2 1001, *et seq*.).

60. *Supra*, note 1, p. 307.

61. *Supra*, note 59.

62. *Supra*, note 1, p. 305.

63. Conversation with Stuart Dobbs, Attorney for SCA, Springfield, Illinois, May 1980.

64. Illinois Seventh Circuit Court, Macoupin County, Consolidated Case No. 77-CH-10, 77-CH-13, Post-trial Brief of *Amicus Curiae*, U.S. EPA, July 10, 1978.

65. *Ibid*.

66. Conversation with SCA Attorney Fred Prillaman, Springfield, Illinois, May 1980.

67. Illinois Appellate Court, Fourth District, No. 77-CH-10, Notice of Appeal, Wilsonville v. SCA, August 28, 1978, Sworn Affidavit of James Douglas Andrews, August 28, 1978.

68. *Ibid*., Exhibit A.

69. *Ibid*., Exhibit A.

70. Conversation with SCA Attorney, Fred Prillaman, Springfield, Illinois, May 1980.

71. *Ibid*.

72. *Ibid*.

HAZARDOUS CHEMICAL WASTES STORED ILLEGALLY AT EASTERN RUBBER COMPANY IN CHESTER, PENNSYLVANIA

Introduction

Between 1974 and 1977 Melvin Wade, through his tire shredding business located along the Delaware River in eastern Pennsylvania, illegally stored and disposed of hazardous waste chemicals, which he obtained from ABM Disposal Services, a waste transport company. Wade disposed of the wastes by emptying the drums onto the ground or into culverts that flowed into the Delaware River. He then resold the drums to recyclers. Wade is believed to have received approximately 50,000 drums of waste.

The Pennsylvania Department of Environmental Resources (DER) discovered the illegal disposal site in March 1977. DER immediately obtained a search warrant and orally ordered the site to shut down. DER later brought administrative action against both Wade and ABM Disposal Services, ordering the site be cleaned up and permanently closed. The site was closed down but neither ABM nor Wade, both bankrupt, took action to clean up the site.

In February 1978 a massive fire broke out on the property causing many of the barrels to explode and the buildings used to store barrels to collapse. Exploding barrels shot off the site, threatening nearby liquified natural gas storage tanks. Clouds of toxic fumes forced the closing of the Commodore Barry Bridge, a major commuter route between Philadelphia and the suburbs of New Jersey. Forty-five firemen were hospitalized for severe toxic smoke inhalation, skin rashes, and burns.

Wade was convicted on criminal charges in August of 1980 and is currently serving a 2-5 year jail sentence. The U.S. Environmental Protection Agency (EPA) has filed a civil suit against Wade; as of October 1981 the case has not gone to trial. EPA has conducted extensive monitoring of the site to determine the extent of the environmental contamination. DER has begun to clean up the site. A complete cleanup of the site is expected to cost $1.25 million to $3 million.

Background Information

The Location--

The Eastern Rubber Tire Company is located on a three-acre tract along the Delaware River in Chester, Pennsylvania, approximately 12 miles southeast of Philadelphia. Its owner, Melvin Wade, established the tire shredding company in 1970.[1] The site is located in a highly industrialized area with a natural gas storage facility located directly north of the property and an approach to the Commodore Barry Bridge directly to the south. The site's eastern border is the Delaware River. Residential property is located approximately 10-15 blocks west of the site, separated from it by commercial and industrial buildings.

Waste Disposal--

In 1974 Wade agreed to accept 55-gallon drums of waste from ABM Disposal Service Company, a waste transporting and disposal firm.[2] The tire-shredding business had been only marginally profitable and several storage buildings stood empty. ABM agreed to pay Wade approximately $1.50 for each drum of waste that he took.[3] It is unclear whether Wade agreed to dispose of the wastes he took from ABM, or merely to store them. However, since there is no indication that ABM expected to reclaim the wastes in the future, it can be assumed that Wade was to dispose of the wastes.

ABM, based in Chester, Pennsylvania, has been in the business of transporting and disposing of waste materials since 1970.[4] The Wade site is one of several ABM used to dispose of the wastes it hauled.[5] ABM's president, Franklin B. Tyson, has a history of state convictions for illegal dumping going back 15 years.[6] In spite of this, companies such as General Electric, Texaco, Scott Paper, Sun Co., Exxon, Dupont, Boeing-Vertol, and Smithkline contracted with ABM to transport and dispose of their wastes.[7] A total of 51 corporations contracted with ABM for transport and disposal of their wastes in 1977-1978.[8]

ABM's transport and disposal charges were very low: approximately $17 per drum, which is considered half the usual cost for disposal of industrial chemicals.[9] ABM's price was so low that, according to the Philadelphia Inquirer, "its customers could hardly have believed that their hazardous wastes were being legally and safely disposed of."[10] ABM apparently was able to undercut its competitors because the company's only expenses were trucking the wastes a few miles to Melvin Wade's property and the $1.50 per barrel it paid Wade.[11]

The wastes ABM delivered to Wade included inflammable, explosive, caustic, acutely toxic, and carcinogenic substances.[12] Wade claims that at the time he received the wastes he thought they were harmless. Wade disposed of the waste by dumping the barrels on the ground or into storm sewers and culverts emptying into the Delaware River. Wade resold the drums he had emptied for $6 apiece to a drum recycling firm nearby.[13] ABM delivered approximately 300 drums of waste per week to the site between 1974 and 1977; the total number of drums delivered to the site is estimated to be more than 50,000.[14]

The Pennsylvania Solid Waste Management Act of 1970[15] requires permits for the operation of processing and disposal systems of solid wastes, including industrial and agricultural chemical residues, and makes it unlawful to dump or deposit wastes without a permit.[16] If a disposal creates a health hazard or a public nuisance, or adversely affects the environment or economic development of an area, permits may be revoked. The Wade site did not have any permits to dispose of wastes and was therefore operating in violation of the Act.

Response--

Discovery of the problem; immediate response--On March 30, 1977, the Pennsylvania Department of Environmental Resources (DER) discovered the Wade disposal site during an investigation of ABM Disposal Services.[17] Prior to the discovery of the site by DER officials, local residents had complained to city officials about noxious odors emanating from Wade's property.[18] However, the city never acted on the complaints.

At the time DER discovered it, the site contained over 10,000 barrels of hazardous wastes as well as seven tanker trucks of liquid chemicals. The barrels were rusted and leaking, creating pools of waste. Because of its proximity to the Delaware River, as well as to residential areas, the site posed a severe threat to the environment and public health. DER immediately obtained a search warrant to investigate the site and on April 1, 1977, orally ordered the site to shut down[19] under authority of the Pennsylvania Solid Waste Management Act. Wade discontinued disposal and storage operations at the site upon DER's order and has kept it closed since then.

On July 1, 1977, DER followed up on its oral order of April 1977 by issuing a formal administrative order requiring Wade to clean up and permanently close the site.[20] Wade, however, failed to clean up the site. In July 1977 DER also issued an administrative order requiring ABM Disposal Services to clean up the site; however, ABM immediately filed a no-asset bankruptcy claim and the site remained contaminated.[21]

Explosion and fire--On February 2, 1978, six months after DER issued its clean-up orders, a massive explosion of unknown origin occurred on the Wade property. The resulting fire destroyed a majority of the tire shredding facility's buildings, forcing Wade into bankruptcy.

At the time of the fire the site still contained approximately 10,000 barrels of chemicals and seven tanker trailers filled with liquid chemicals.[22] Over 5,000 of the barrels had been stored inside the tire facility's buildings, which collapsed during the fire, burying the wastes. The remaining barrels of waste, stacked in open storage areas around the property, either exploded or were severely ruptured during the fire. Fewer than 1,000 of the 10,000 barrels remained intact.[23]

The explosion and fire endangered a large liquified natural gas storage tank and ten to twenty tanks filled with propane at an electrical plant within 200 yards of the Wade site. Fortunately, the tanks were not harmed.

Toxic fumes from the fire forced the closing of the Commodore Barry Bridge, a major commuter route between Philadelphia and New Jersey, which runs along the southern end of the site.

Forty-five firemen were hospitalized as a result with injuries ranging from severe toxic smoke inhalation to skin rashes and minor burns.[24] The injuries were extensive because highly caustic chemicals damaged the firemen's protective clothing. The firemen were unprepared for the fire because they were not aware that the site, which they thought was just a tire shredding facility, had been used as a storage area for chemical waste.

The Chester fire department is composed of both volunteer and paid employees. The city paid the hospitalization costs for the salaried firemen, but not for the volunteers.[25] The volunteer firemen have considered bringing a class action suit against the City of Chester to get compensation for their medical expenses .[26]

The aftermath of the February fire intensified the health and environmental hazards posed by the site. Thousands of disintegrating and leaking barrels that had once contained such chemicals as sodium copper cyanide, benzene, and phenol covered the property.[27] The chemicals formed open cesspools on top of the soil, seeped into underground water sources, and caused toxic runoffs into the Delaware River. Heavy metals, such as nickel, copper, and lead accumulated in the river sediment as well as unknown amounts of chemicals that were carried downstream.[28] Additional smaller fires continued to erupt after the February fire, a result of spontaneous explosions from the mixing of highly combustible chemicals from the leaking drums. The smaller fire generated visible smoke and fumes. Among the chemicals identified is cyanide, which when mixed with acid can produce a lethal gas.[29]

Enforcement and cleanup--The explosion of the Wade site brought the problem of cleaning up the site to the forefront of local residents' attention. In February 1978, in response to the fire, Chester residents formed the Wade Dump Site

Committee to pressure for enforcement action and cleanup of the site. The Committee has concentrated its efforts on three areas of concern: seeking compensation for volunteer firemen that were injured in the fire, investigating possible injuries to residents' health, and pressuring the state to clean up the property.[30]

The Committee successfully pressed the District Attorney's Office to bring criminal charges against Wade. On May 9, 1979, after a year of investigation, Wade was charged with causing a catastrophe, failing to prevent a catastrophe, and three counts of illegal dumping under the Pennsylvania Clean Streams Act.[31]

Wade did not appear for a pretrial hearing on the criminal charges in March 1980 nor for the original trial date in April 1980. However, in August of 1980 Wade was convicted and in January of 1981 was sentenced to 2-5 years in jail.[32]

The Wade site remained severely contaminated after the February 1978 fire. Preliminary tests in January1979, done by EPA, have identified over forty-five hazardous chemicals in the open drums found on the site.[33] Hazardous wastes have migrated from the site to the Delaware River through runoff and percolation through the soil.[34] Analyses of air samples taken at the site indicate that the hazardous wastes have volatilized and that fumes from the wastes are migrating from the site to nearby residential and commercial areas.[35]

Based on the results of these tests, EPA on April 13,1979 filed a complaint against Wade and ABM Disposal Services under Section 7003 of the Resource Conservation and Recovery Act of 1976,[36] which authorized EPA to bring suit against sites presenting an "imminent and substantial endangerment to health or the environment." In its suit, EPA asks the court to enjoin Wade and ABM from using the site for waste disposal, and to order the defendants to clean up the site. As of October 1981 a trial date for the suit still has not been set.

The site was unfenced and freely accessible after the February 1978 fire. Children played on the site, residents collected empty barrels for trash containers, and scavengers used cutting torches to remove pieces of the burned-out buildings. Concerned citizens began pressuring city officials to erect a fence around the property, but the city said no money was available for such a project. Finally, in July 1979, a year and a half after the fire, DER erected a fence around the property.[37]

DER however started to clean up the site even before EPA's suit to force cleanup has been resolved, because it feels that the wastes on the site are too hazardous to remain there. DER retained a consulting firm in August 1979 to develop a comprehensive plan for cleanup of the Wade site.[38] The plan includes three phases: identification and removal of intact drums; hydrogeological testing of soil and river sediment; and removal of contaminated soil or alternative measures to prevent further chemical runoff into the Delaware River.[39] In February 1980 Rollins Environmental Services began the first phase of cleanup operations by identifying and removing intact drums of waste from the site.[40] Problems such as the discovery of drums filled with PCBs which required special handling as well as collapsed buildings in which the wastes were stored added to the difficulty of preliminary cleanup efforts. The wastes removed from the site have been transported ten miles away to an approved disposal facility owned by Rollins in Bridgeport, New Jersey.[41]

DER payed for the preliminary cleanup, at an estimated cost of $650,000, with Clean Water Fund monies, financed by fines imposed on polluters. It estimates that the ultimate cost of disposing of the drums that are on the site may be $1,200 per barrel.[42] Proper disposal of the waste at the outset would have cost $50 to $100 per barrel.[43] DER does not believe that it can recover from Wade or ABM the cost of the cleanup becuase both are bankrupt. However, DER plans to file suit to place a lien on Wade's remaining property.[44]

The second phase of the cleanup involves a series of hydrogeological tests in order to evaluate the degree of contamination and the potential pollution of the soil, groundwater, and the Delaware River. DER, whose available funds were exhaused in the first phase of the cleanup, has secured EPA funding for the study.[45]

The full extent of contamination has not yet been determined, but EPA's preliminary tests have detected over fifty chemicals in samples taken from topsoil, as well as substantial concentrations of heavy metals in river-bottom sediment.[46] Until the study is complete, EPA can only speculate on the alternatives available for the ultimate decontamination of the site and the Delaware River.

Among alternatives under consideration for decontaminating the site is removing all topsoil. This alternative is the most costly, and a major problem with it would be the hazard to surrounding residents and workers that would be created from stirring up dust contaminated with toxic chemicals during the cleanup. Other measures available include installing a "berm" on top of the soil along the river bank in order to prevent surface water runoff, or a "grout curtain,"

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an impermeable shield installed underground, to prevent further groundwater contaminaton."[47]

However, if contamination is severe, the only effective alternative may be the complete removal of soil. These measures would prevent further contamination of the Delaware River. However, if EPA's study reveals extensive sediment contamination, dredging the Delaware River may be necessary as well. The total cost of these measures for a comprehensive cleanup, including cleanup of the site and the river, have been estimated to be from $1.25 million to $3 million.[48]

Costs

Private Costs of Waste Disposal--

Actual cost of illegal disposal--The private costs of illegal disposal of hazardous wastes on the Wade site are compared to what would have been the costs of proper disposal. The private costs include the market transactions between the waste generators and ABM Disposal Services for the transportation of the chemical wastes, and secondly, the agreement between ABM and Eastern Rubber Company, for the storage and disposal of the wastes.

ABM Disposal Services charges approximately $17 per 55-gallon drum to transport and dispose of the generator's chemical and highly toxic wastes.[49] The $17 figure is about half of what industry experts say is the usual cost for the safe disposal of the wastes.[50]

ABM, in an agreement with Melvin Wade, owner of Eastern Rubber Company, paid Wade $1.50 per 55-gallon drum to accept the chemical wastes.[51] ABM's profit for hauling the wastes to an illegal site thus was roughly fifteen dollars per 55-gallon drum. Wade, in turn, emptied several thousand of the 55-gallon drums by spilling their contents on the ground and then resold the drums for approximately $6.00 each to a drum reprocessing company nearby.[52]

Comparative cost of proper disposal--Proper disposal of the hazardous wastes on the Wade site would have cost approximately $35 to $50 per 55-gallon drum.[53] This estimate is based on the average waste disposal charges of legally permitted disposal facilities located in the vicinity of the site.

Social Costs of Illegal Disposal--

The social costs resulting from the illegal disposal of hazardous wastes on the Wade site include damage to natural resources, human health, and property.

Natural resource damage--The Wade site is severely contaminated with the hazardous chemical wastes that were stored and disposed of there.

Analyses of wastewater samples taken from storm sewers on the Wade site indicate that the wastes have migrated into the Delaware River. Preliminary test results have fund substantial concentrations of heavy metals in the Delaware River, including chromium, nickel, copper, and lead.[54] Because the site is near the Delaware River and has a high-water table, wastes can be expected to continue to migrate from the site into groundwater wources and into the Delaware River via surface runoff and underground percolation.[55] Air samples taken at the site indicate that fumes from volatilized hazardous wastes are present over the site, and that the fumes have migrated to nearby residential and commercial areas.[56]

To fully assess natural resources damage, DER, in conjunction with EPA's National Environmental Investigation Team (NEIS), began testing the air, water, and soil at the site in July 1979.[57] DER has secured funding from EPA under Section 311 of the Federal Water Pollution Control Act to study the extent of chemical contamination in the Delaware River.[58]

Property damage--Wade claims his property would be worth up to $4 million after cleanup, but the most prospective buyers have offered for it in its present condition is $750,000.[59] Residential property values have decreased in the area surrounding the Wade site, but the extent of devaluations has not been estimated. Local residents within a fifteen-block area adjacent to the site are concerned that due to noxious fumes and the potential soil and water contamination they will be unable to sell their homes.[60]

Health effects--The wastes present at the Wade site are acutely toxic, mutagenic, and carcinogenic, affect the nervous system, and bioaccumulate.[61] They present a severe potential threat to human health both individually and through possible synergies.

Acute health effects were suffered by the firemen who fought the blaze that consumed the site in February 1978. Forty-five firemen were hospitalized as a result of the fire. The health injuries reported were severe smoke inhalation of toxic fumes, and minor skin rashes and burns.[62] Many firemen were burned by the highly acidic and corrosive chemicals which ate holes through their clothing. The firemen were unprepared for the fire because they were not aware that the rubber plant's facilities had been used as a storage area for chemical waste. The City of Chester has paid the hospitalization costs of salaried firemen,[63] but the volunteer firemen who were injured have not recovered the costs of their injuries.

People living near the site have complained about difficulty in breathing, burning eyes, coughs, skin rashes, and nausea. The Center for Disease Control in Atlanta is currently working with the Wade Dump Site Committee to gather information on the health effects.[64] The Committee is taking a door-to-door survey of a fifteen-block area surrounding the site.

Because many of the wastes present at the site exert slow working and insidious health effects, latent damage to the health of area residents is a real possibility.

Enforcement and Litigation Costs--The public litigation costs at the present time include the pre-trial expenses in the U.S. EPA's civil action suit against Wade and ABM, as well as Delaware County's criminal action against Wade. The cost figures are limited to man-hours invested in the cases as of June 1980.

As of October 1981 EPA's action against Wade has not gone to trial, fully three years after initial involvement with the site.[65] EPA's Region III Office, having primary responsibility in the action against Wade, had, by 1980, invested approximately one-and-a quarter man years of effort, with forty percent of this in attorneys' time alone.[66] In addition, EPA headquarters, Department of Justice, and the Pennsylvania Attorney General had spent approximately one-tenth of a man year on the Wade Case.[67]

Delaware County's criminal action against Wade, initiated in February of 1978, consumed approximately one-half of a man year's effort in attorneys' time, as well as an additional one-quarter of a man year in investigative work before the case went to trial in August of 1980.

Cleanup costs--The EPA's study of the contamination of the Delaware is expected to cost between $150,000 and $225,000, paid for through Section 311 funding of the Clean Water Act.[69] DER which spent $650,000 on initial remedial actions, has exhaused its fund. A complete cleanup of the site, however, will cost from $1.25 million to $3 million.[70] Additional remedial action money for PCB cleanup may be provided under Superfund; as of October 21, 1981 EPA's decision to provide Superfund money is still pending.[71] DER estimates that the ultimate cost of disposing of the drums on site may be $1,200 dollars per barrel. The original costs of disposal at an approved site would have been $50 to $100 per barrel.[72]

Cost Redistribution--

EPA's suit against Wade and ABM asks the court to order the two defendants to clean up the site to EPA's satisfaction. This would shift the cost of cleanup from the government to the parties that contaminated the site. However, because both Wade and ABM have declared bankruptcy, their ability to pay for a cleanup seems doubtful. In fact, DER does not expect to be able to recover from Wade or ABM the $650,000 it is spending on a preliminary cleanup, although it plans to place a lien on Wade's remaining assets.[73]

The volunteer firemen who were hospitalized as a result of the fire at the site are considering suing the City of Chester to gain compensation for their medical expenses. This would shift the cost to the city, but not to the parties ultimately responsible for the firemen's injuries, i.e., ABM and Wade.

So far no residents in the vicinity of the Wade site have brought suit for compensation for possible health effects or loss of property value.

Footnotes

1. Ben. A. Franklin, "Cleaning Up Toxic Wastes," New York *Times*, April 22, 1979.
2. *Ibid*.
3. *Ibid*.
4. Nordland and Friedman, "Poison at Our Door Step Series," Philadelphia *Inquirer*, September 24, 1979.
5. *Ibid*.
6. *Ibid*.
7. *Ibid*.
8. *Ibid*.
9. *Ibid*.
10. *Ibid*.
11. *Ibid*.
12. EPA v. Wade, No. 79-1426 (E.D. Pa., March 30, 1979) amended complaint.

13. Ben. A Franklin, "Cleaning Up Toxic Wastes," New York *Times*, April 22, 1979.

14. Memorandum of Points and Authorities, EPA v. Wade (E.D. Pa. April 13, 1979).

15. Pennsylvania Solid Waste Management Act, §§7, 9, 1968 Pa. Laws, as amended 1972.

16. *Ibid*.

17. *Supra*, note 13.

18. Conversation with Gene Hains, Director, Wade Dump Site Committee, May 1980.

19. *Supra*, note 13.

20. Conversation with Keith Welks, Attorney, Pennsylvania DER, May 1980.

21. *Supra*, note 4.

22. Wade Dump Site Committee, Report on Wade Site Fire, 1979.

23. *Ibid*.

24. *Ibid*.

25. *Supra*, note 18.

26. *Ibid*.

27. *Supra*, note 12.

28. *Ibid*.

29. Dixon and Beldon, "Cancer Peril Found at Dump," Philadelphia *Inquirer*, February 8, 1980.

30. *Supra*, note 18.

31. Conversation with John Crane, Attorney, Delaware County, May 1980.

32. Conversation with Keith Welks, Attorney Generals Office, October 21, 1981.

33. *Supra*, note 12.

34. *Ibid*.

35. *Ibid*.

36. Memorandum of Points and Authorities, U.S. EPA v. Wade, No. 79-1426 (E.D. Pa., April 13, 1979). Resource Conservation and Recovery Act of 1976, as amended, 42 U.S.C. §6973.

37. Conversation with Gene Hains, Wade Dump Site Committee, May 1980.

38. Conversation with Keith Welks, Attorney, Pennsylvania DER, May 1980.

39. "Contract for 'Wade Dump' Cleanup Effort," Delaware County _Times_, March 27, 1980.

40. _Ibid_.

41. _Supra_, note 20.

42. _Supra_, note 20.

43. _Supra_, note 4.

44. _Supra_, note 20.

45. _Supra_, note 20.

46. _Supra_, note 12.

47. Conversation with Joe Donevon, EPA Region III, Attorney, July 15, 1980.

48. _Ibid_.

49. _Supra_, note 4.

50. _Ibid_.

51. _Ibid_.

52. _Ibid_.

53. _Ibid_.

54. _Supra_, note 12.

55. _Ibid_.

56. _Ibid_.

57. Conversation with Joe Donevon, Attorney, EPA Region III, May 1980.

58. *Supra*, note 20.

59. Gail Becker, "Dump Owner Freed," *The Bulletin*, Chester, Pennsylvania, December 27, 1979.

60. Conversation with Gene Hains, Wade Dump Site Committee, June 1980.

61. Harry Hartland, "Wade Dump Called Worst in Five States," Delaware County *Daily Times*, December 21, 1979.

62. *Supra*, note 4.

63. Conversation with Gene Hains, Wade Dump Site Committee, June 1980.

64. Phillip Dixon, "Evidence 'Soft' at Dump Site," Delaware County *Daily Times*, January 15, 1980.

65. Conversation with Joe Donevon, U.S. EPA Region III, Attorney, June 1980.

66. *Ibid*.

67. *Ibid*.

68. Conversation with John Drane, Attorney for Delaware County, Pennsylvania, June 1980.

69. Conversation with Keith Welks, Pennsylvania DER, Attorney, June 1980.

70. *Ibid*.

71. Conversation with Keith Welks, Attorney Generals Office, October 21, 1981.

72. *Ibid*.

73. *Ibid*.

PCB DUMPING IN NORTH CAROLINA

Introduction

In late July and early August, 1978, Robert Burns and his two sons secretly dumped approximately 30,000 gallons of transformer oil containing PCBs, a highly toxic and persistent chemical, along the shoulders of 211 miles of roads in North Carolina. Burns had obtained the transformer oil from the Ward Transformer Company of Raleigh, North Carolina. Federal regulations issued in the spring of 1978 permitted PCB oil to be disposed of only in incinerators, but since no approved incinerators were in operation in August 1978, the oil could only be stored.

The state of North Carolina has covered the PCB-contaminated soil with activated carbon and asphalt. After studying methods of both treating the contaminated soil on site and removing the soil for disposal elsewhere, the state has proposed to remove the soil and dispose of it in specially constructed landfill in Warren County, North Carolina. A court restraining order has thus far prevented the state from carrying out this proposal.

Damage from the dumping includes possible latent health effects from PCBs, which are suspected of carcinogenic, mutagenic, teratogenic, and behavioral effects and loss of crops growing near the contamination.

Background Information

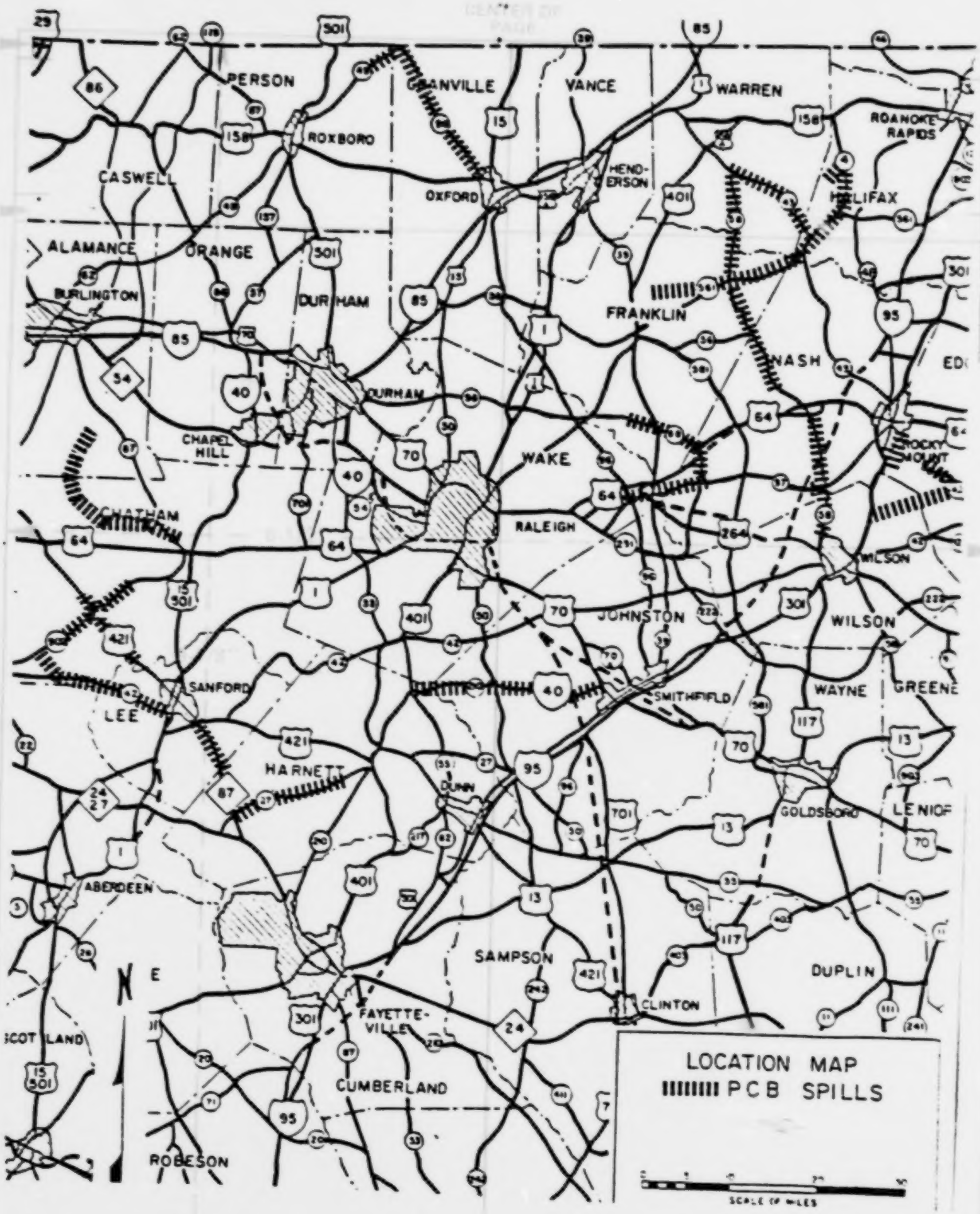
The Location--

Burns and his sons dumped PCB oil along 211 miles of road shoulders in fourteen North Carolina counties, mostly in rural areas. (See Figure B-3.)[1]

Waste Disposal--

Discovery--In the last week of June, 1978, a mixture of liquid chemicals, later identified as PCB liquids, was discharged along remote roads within the Fort Bragg Military Reservation. Fort Bragg personnel investigated the discharge and took samples of the contaminated soil, but apparently the samples were not analyzed and no further action was taken.[2]

In late July 1978, private citizens reported a similar discharge to the North Carolina Highway Patrol. This discharge had occurred on July 27 and 29, 1978 along the shoulders of North Carolina Route 28 north of the Town of Centerville in Warren County, North Carolina. The Highway Patrol notified the state Division of Health Services, who in turn notified the Water Quality Program of the Department of Natural



PERSON
GRANVILLE
VANCE
WARREN
ROXBORO
ROANOKE RAPIDS
CASWELL
OXFORD
HENDERSON
HALIFAX
ALAMANCE
ORANGE
BURLINGTON
DURHAM
FRANKLIN
NASH
CHAPEL HILL
WAKE
ROCKY MOUNT
CHATHAM
RALEIGH
WILSON
JOHNSTON
SANFORD
SMITHFIELD
WAYNE
GREENE
LEE
HARNETT
DUNN
GOLDSBORO
LENIOR
ABERDEEN
SAMPSON
DUPLIN
CLINTON
FAYETTEVILLE
SCOTLAND
CUMBERLAND
ROBESON
LOCATION MAP
PCB SPILLS
SCALE OF MILES

Figure B-3. Location of PCB Spills in North Carolina

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TYPING GUIDE SHEET

Resources and Community Development (DNRCD). Personnel from the Raleigh field office of the Water Quality Program on July 31 investigated the discharge as if it were an oil spill. Since they could find no oil ponded or evidence of oil in surface waters, the investigators returned to their offices without taking further action.[3]

On August 2, 1978, a farmer in Johnston County complained to the Water Quality Operations Branch of the Division of Environmental Management that vapors from a spill on North Carolina Route 210 in front of his farm were giving his workers headaches and nausea. The Division sent a chemist to the scene to investigate the spill. The chemist took samples of grass, soil and water from the site for analysis. On his way home from work that day, the same chemist encountered a similar spill along State Route 1004 near Snow Hill in Alamance, and took soil samples of that spill as well.[4]

By August 4, 1978, the DNRCD reported that it had identified the material discharged along the road in Johnston County as Aroclor-1260, a preparation of polychlorinated biphenyls (PCBs).[5]

As soon as this identification was made, the DNRCD notified the emergency response branch of the regional office of the Environmental Protection Agency, the North Carolina Attorney General and the North Carolina Department of Crime Control and Public Safety. Law enforcement officials throughout the state were notified of the spills by means of the Police Information Network, and news of the spills was released to the press.[6]

Extent of spill--As the spills and the identification of PCBs were publicized, reports of additional spills came in from highway patrol officers, highway maintenance personnel, and private citizens. Gradually the extent of the pollution became clear. Although there were some spills in June and July, most of the spills took place on the nights of August 1, 2 and 3, 1978; additional spills may have occurred on the nights of August 5 and 8, 1978.[7] Altogether, 211 miles of road shoulders in fourteen counties were contaminated with the PCB oil.[8] For the most part, the contaminated roads are in rural areas. Approximately 30,000 to 35,000 gallons of PCB oil were discharged along the roads, contaminating roughly 40,000 cubic yards of soil.[9] The strip of contaminated soil is approximately four inches wide. Samples of contaminated soil were found to have PCBs in concentrations ranging from 6.5 to 7.5 milligrams of PCB per gram of soil.[10]

Response--

Protection of public health--As soon as PCBs were identified in the discharged oil, the DNRCD notified the emergency response branch of the regional office of the Environmental Protection Agency, the North Carolina Attorney General, and the state Department of Crime Control and Public Safety. Law enforcement officials throughout the state were notified of the spills by means of the Police Information Network, and news of the spills was released to the press.

On August 5, officials from the Water Quality Operations Branch met with persons living along some of the affected roads. At the request of some of the residents along North Carolina Route 210, the state Department of Transportation on August 5 and 6 covered the spill along that road with a layer of sand to suppress the odors given off by the discharged liquid.[11] These odors were from the chlorinated benzene solvents that were in the PCB mixture, and not from the PCBs themselves.[12]

On August 15, the governor of North Carolina requested the President of the United States to declare the affected counties a disaster area in order to qualify for federal aid. The governor also asked the federal government for aid from the Federal Highway Emergency Assistance Fund. Both these requests for federal aid were denied.[13]

The Division of Health Services within the Department of Human Services first briefed local health directors on the PCB spills and then, as the public demanded more information, issued a notice August 16, 1978 on the health effects of the spill. In this notice the Department advised people to avoid contaminated areas, and not to eat produce from nor graze cattle on those areas. Nonetheless, the Department stressed that the PCB contamination posed no health threat. The Department on August 18 also took blood samples from residents exposed to particularly high levels of PCBs. The tests did not detect higher than normal levels of PCBs in these persons.[14]

The state Department of Agriculture in mid-August found some sampled crops from fields along the spill routes had become contaminated with PCB-tainted dust. As a result of this, the Department on August 25, 1978 issued an advisory warning against human consumption of crops grown within 100 yards of the contamination. It also cautioned farmers not to use pasturage growing within 100 yards of the contamination to feed livestock intended for human consumption, and urged that the first four to five rows of feed corn growing along the contaminated roads be plowed under. Agricultural extension agents delivered this advisory in person to people living along the contaminated roads. The Department issued a second advisory August 29, repeating the warning of the first advisory, and asking that gardens within 100 yards of the contamination be plowed under; many persons are reported to have done so.[15]

After conducting further tests, the Department of Agriculture issued a third notice September 14, 1978, advising the public that consumption of garden produce grown near the spills would present no unreasonable risk to health provided the produce was peeled or well washed. The Department sill advised farmers not to graze dairy or beef cattle within one hundred yards of the spills since those animals would concentrate PCBs in their milk and flesh.[16]

To prevent the spilled PCBs becoming more widely dispersed in the environment, the state Department of Transportation on August 28 began to cover the PCB-contaminated soil with a 10% solution of activated carbon. The carbon was intended to absorb and bind the PCBs. A coating of liquid asphalt was then applied on top of the carbon solution to prevent erosion.[17] As of October 1980, the PCB -contaminated soil remains along the 211 miles of roadway shoulder, covered with carbon and asphalt.

Enforcement--After a large-scale investigation involving North Carolina, EPA and New York State officials, a North Carolina grand jury August 28, 1978 charged Robert Burns and his sons Randall and Timothy Burns with operating the tank truck that sprayed the PCB oil along the North Carolina roads.[18] Robert Burns is the owner of Transformer Sales Co. of Allegheny, New York, a small company that salvages, transports, stores, and resells PCB oil from transformers.[19]

He and his sons were identified by eyewitnesses who had helped the Burnses one night when the truck they were using for dumping ran off the road and had to be towed.

Burns said that he had obtained the PCB oil from the Ward Transformer Company in Raleigh, North Carolina with the understanding that the would dump the oil in the manner that he did. The Ward Transormer Company, on the other hand, maintains they paid Burns to take the oil with the understanding that he would store it at his facility in New York and recycle it.

Because at the time there was no one state law specifically prohibiting the dumping of toxic substances, the Burnses were indicted under a variety of laws: they were charged with two counts of felonious damage to public property (i.e., the shoulders of state roads, which the state owns or for which the state holds the right-of-way), felonious conspiracy to damage public property, felonious criminal nuisance, two counts of misdemeanor injury to growing plants, and misdemeanor operation of a disposal system without a permit. The indictment covered only dumping in Halifax County. That county was chosen for charging the Burnses because eyewitnesses had seen the Burnses dumping there.[20]

At the federal level, disposal of PCBs is regulated by the Toxic Substances Control Act,[21] which provides for civil penalties of up to $25,000 per day and criminal penalties of up to $25,000 per day and imprisonment for up to one year for violation of the disposal regulations.[22] In January 1979, a federal grand jury returned an indictment against the Burnses charging them with violating the Toxic Substances Control Act.

In a plea bargaining arrangement, the Burnses eventually pled guilty to reduced charges in both the state and federal cases in return for testifying against two persons at the Ward Transformer Company who are suspected of complicity in the dumping, Robert Ward, Jr. and Robert Ward III. Robert Burns received prison sentences of three to five years in the State case and one and one-half years in the federal case; both he and his sons received probationary sentences in the state and federal courts.[23]

Robert Ward, Jr. runs the Ward Transformer Company of Raleigh, North Carolina, which supplied the PCB oil to the Burnses for disposal. The Ward Transformer Comapny is a closely-held family corporation that buys, sells and rebuilds surplus electric transformers and manufactures dry transformers and switching gear. The company, which has been in business approximately fifty years, has annual sales of roughly $5 million and employs 110 persons.[24]

On January 22, 1979, a North Carolina grand jury indicated the Wards on two counts of serving as accessories before the fact and one count of conspiracy in connection with the dumping.[25] A federal grand jury indicted the Wards for violating the PCB disposal requirements of the Toxic Substances Control Act.

The Wards have been tried on the state's charges. The elder Wards has been acquitted and charges against the younger Ward were dropped.[26] In the federal case Ward was convicted and sentenced to two and one-half years in prison, a five year probation term, and a $200,000 penalty.[27]

Although the culprits were apprehended in this case, the probability at that time that a person dumping PCBs would be caught may not have been too great. In August 1978 there was no law in North Carolina specifically banning the dumping of toxic wastes, and in the absence of law, there were no enforcement officials other than peace officers to catch persons like the Burnses dumping wastes.

Under federal law, the Toxic Substances Control Act prohibited such dumping but the regional EPA office charged with enforcing the Toxic Substances Control Act was not fully staffed in August 1978. At that time there were only two field personnel to enforce the Act within the entire region, and enforcement guidelines to direct these personnel had not yet been devised.[28]

To close the gap in the legal framework that prevented state prosecutors from charging the Burnses under one specific law, North Carolina has enacted a statute making it a felony to dump toxic substances, punishable by a fine of up to $100,000 per day or imprisonment.[29]

Cleanup--Covering the PCB spills with activated carbon and asphalt was only a temporary solution intended to immobilize the PCBs until a permanent means of cleaning up the contamination could be devised. The state, which has assumed responsibility for the cleanup, had two alternatives for a permanent solution available to it: it could attempt to treat the contamination where it lay on the shoulders (in situ treatment) or it could remove the contaminated soil for disposal elsewhere. If the second alternative were chosen, the soil could be disposed of at the nearest existing EPA-approved PCB landfill, which is in Alabama; incinerated; or disposed of in a landfill constructed in North Carolina especially for this contaminated soil.

Removal of contamination--The state initially chose to remove the contaminated soil, and it developed a method for doing so. The shoulders with PCB contamination would be thoroughly wetted down, the contaminated soil would be trenched out and fed into waiting trucks, and then the shoulders would be reshaped and seeded. The state tested this method on October 5, 1978 along one mile of PCB-contaminated North Carolina Route 58 in Warren County. Tests showed that the removal did not significantly increase ambient levels of PCB in the air and did not expose the workers conducting the removal to the PCBs.[30] The state had to overcome local opposition before it could test the removal method. The Warrenton Town Board objected to the test because the state planned to store the soil removed during the test in a highway maintenance shop yard near the town's water supply. The town obtained a restraining order prohibiting storage of the soil in the maintenance yard on September 21, 1978, just before the test was originally scheduled to be conducted. The state secured a more remote, privately-owned site for storing the removed soil and the test then was carried out.[31]

Disposing of the soil that would be removed by a full-scale removal operation was the next hurdle to be overcome. Incineration of the soil was rejected because thus far there are no EPA-approved PCB incinerators, and because given the volume of soil to be disposed of, incineration would be too costly. Disposal of the soil in the existing EPA-approved PCB landfill in Alabama was also rejected. It was estimated that using the landfill would cost $12 million, largely because of the expense of transporting the contaminated soil, and this was considered prohibitive.[32] It is also an open question whether the state of Alabama would have accepted so much hazardous waste from another state.

Problems in siting a disposal facility--Having rejected these two alternatives for disposing of tne contaminated soil, the state began to look for a suitable landfill site in North Carolina. After considering over 100 sites,[33] the state settled on a site in Chatham Couunty, and on November 21, 1978 the Chatham County Board of Commissioners voted to sell the state six acres of land in the county landfill for construction of a permanent disposal facility for the contaminated soil. Public opinion in Chatham County was strongly opposed to this plan, however. Because of the opposition, on December 15, 1978, the state withdrew its offer to purchase the land, and on December 18, 1978, the County Commissioners reversed themselves and voted not to sell the land to the state.[34]

The state next turned to a site in Warren County (see Figure B-4). The site was privately owned and its owners were willing to sell it to the state. The state applied to EPA on December 12, 1978 for the necessary permit and asked EPA to waive four requirements contained in EPA's regulations for chemical waste landfills, namely, that it be permitted not to use an artificial liner within the landfill, that the distance between the bottom of the landfill and the seasonal high groundwater table be ten rather than fifty feet, that it not be required to analyze groundwater for chlorinated hydrocarbons, and that it not be required to install a leachate collection system.[35]

Because the land at the Warren County site was privately owned, approval from County officials was not necessary as it was in Chatham County. However, on January 2, 1979, the Warren County Board of Commissioners passed a resolution objecting to locating a permanent PCB disposal site within the county.[36] Warren County residents and state environmental organizations expressed their strong opposition to the proposed landfill, singling out for particular attention the requested waivers of EPA's chemical landfill regulations, which they felt would make the landfill more hazardous. The Board of Commissioners of neighboring Vance County entered the fight, resolving on April 2, 1979 that it "opposed and strongly objected to" PCB disposal in Warren County or any of four other nearby counties.[37] However, the state continued with its plans, and on June 4, 1979 received a permit from EPA for the proposed Warren County landfill. EPA granted three of the requested waivers, but denied the request for a waiver of the leachate collection system requirement.[38]

Because of the opposition aroused by the two efforts to site a landfill for the contaminated soil, the state in early 1979 began to explore other alternatives. The state reconsidered *in situ* treatment of the contamination, and in February 1979 tested an *in situ* method proposed by Dr. Jerome B. Weber of North Carolina State University. On the theory that the activated carbon had immobilized the PCBs, Dr. Weber proposed to till fertilizer and lime into the contaminated shoulders and then plant them with grass. The grass would be monitored to ensure that it was not taking up the carbon-fixed PCBs. Eventually, Weber believed, microorganims would break down the PCBs. The state tests indicated that this treatment method would be effective, and the governor threw his support behind it. EPA also conducted tests, however, and these tests found that the PCBs were still bioavailable even though they were bound in the activated carbon. As a result, on June 4, 1979, EPA denied the state's request for the waiver of regulations that would have been necessary to carry out the *in situ* method.[39]

After this setback, the state considered using multiple disposal sites because of continuing strong opposition to using the Warren County site. Since residents in a given county could be expected to oppose having their county serve as the disposal site for PCB-contaminated soil from other counties, the state proposed to dispose each county's contaminated soil in its own county landfill. However, some of the fourteen county landfills that would be used in this plan are geologically or hydrologically unsuitable for PCB disposal. Of the fourteen counties, less than one-third approved the plan; the remainder either opposed the plan or temporized.[40]

Since neither the *in situ* nor multiple site approaches seemed feasible, the state returned to its plan of disposing of all the contaminated soil in a specially-constructed landfill in Warren County. This plan, however, soon ran into legal roadblocks.

On August 16, 1979, Warren County sued the state of North Carolina and the owners of the land on which the landfill would be situated, seeking to prevent the state from purchasing the tract of land on grounds that the landfill would constitute a public nuisance, that it would be in violation of federal regulations, and that an Environmental Impact Statement should have been filed under state law.[41] That same day the court issued a temporary restraining order forbidding the sale of the tract to the state.[42]

On August 21, 1979, the Warren County Board of Commissioners passed a resolution prohibiting the storage or disposal of PCBs or materials contaminated with PCBs within the boundaries of Warren County.[43] Warren County amended its complaint twice, first on August 22, 1979 to add as a cause of action the enforcement of the August 21 resolution, and then on September 14, 1979, to add the Regional Administrator of EPA as a defendant, charging that EPA should have filed an Environmental Impact Statement regarding the approval of the disposal site.

On September 6, 1979, the court issued a preliminary injunction prohibiting the state from clearing or grading the Warren County site and from storing or disposing of PCBs at the site.[44] The state, however, was not enjoined from buying the tract of land on which the landfill would be constructed, and it subsequently bought the land.

On September 22, 1979, owners of land adjacent to the Warren County site, Henry F. and William Twitty and Jean Adams, also filed suit against the state, seeking an injunction against dumping PCBs at the site. The landowners brought suit under the same causes of action as did Warren County, and in addition claimed that use of the site as a PCB dump would deprive them of their property without compensation and due process of law.[45]

EPA, on September 28, 1979, successfully petitioned the U.S. District Court for the Eastern District of North Carolina to remove the case to its jurisdiction. After the landowners on November 18, 1979 amended their complaint to include the Regional EPA Administrator as a defendant, EPA on January 21, 1980 successfully petitioned to have that case removed to federal court as well. The two cases will be combined for trial. A trial date has not been set.

Warren County residents are opposed to having the PCB landfill constructed in their county for several reasons. First, of course, is the natural fear of having hazardous materials stored nearby. Besides that, residents feel that the waivers of EPA's regulations will make the landfill more hazardous. Residents also suspect that the state plans to use the site for disposal of other hazardous wastes after the PCB-contaminated soil has been disposed of. In support of this theory, they point out that the state has purchased a 142-acre tract, when only 16 to 20 acres would be necessary for the PCB landfill alone. Warren County is poor, and residents fear that the landfill will scare off new industries, especially the food processing industry, that might otherwise be inducted to locate in the county. There is some sentiment that Warren County was chosen as the site for the landfill because it lacks effective representation. The county is of course represented in the state legislature and in Congress, but none of the legislators representing the county are residents of the county.[46]

The state's plans to dispose of the soil contaminated with PCBs in Warren County have been blocked by a 1978 restraining order still in effect as of October 1981. The contaminated soil remains along the roadsides.

Private litigation--On July 7, 1980, a person living along one of the spill routes, T. Mitchell Langdon, brought a class action suit against numerous North Carolina state officials, EPA officials, the Burnses, Robert E. Ward, Jr., and the Ward Transformer Company.[47] Langdon asked the court to order the defendants to collect and remove the soil along the spill routes that is contaminated with PCBs. He is also seeking up to $10 billion in damages from the defendants for himself and for the class of people who own property along the spill routes, live along the spill routes, or travel on them.

Costs

Private Acosts of Disposal--

Actual cost of illegal disposal--According to the state, the Ward Transformer Company paid the Burnses approximately $1.70 per gallon to dispose of the PCB oil, with the agreement that 70 cents per gallon would be returned to Ward Transformer as a cash kick-back. The kick-back presumably was arranged to evade taxes.[48] Other than the cost of acquiring and operating a 750-gallon tank truck, there were no direct private costs associated with illegally dumping the PCB oil along the roadsides.

Comparative cost of proper disposal--The appearance of new EPA regulations [49] on disposal of PCBs shortly before the North Carolina dumping took place severely restricted the range of alternatives available to a firm like the Ward Transformer Company that wished to get rid of PCB oil. These regulations, which took effect Aptil 18, 1978, require that liquid PCB mixtures, such as the ones removed from the Wards' be disposed of by incineration in an EPA-approved incinerator. In August 1978, there was no such approved incinerator in existence, meaning that PCB oil could not be disposed of, but could only be stored.[50]

A rough idea of the comparative costs of storing PCB oil in compliance with the EPA regulations can be gained from price information supplied by Holley Electric Corporation, a PCB oil storage facility in Jessup, Georgia. Holley charges roughly $12 per drum of oil per month of storage, the equivalent of $0.22 per gallon per month. Transportation to the storage facility is not included; Holley charges $2.44 per loaded mile to transport PCB oil; a load consists of approximately 80 barrels.[51]

Although there still are no approved PCB incinerators, an incinerator run by Rollins Environmental Services of Deer Park, Texas appears to be close to receiving EPA approval. Rollins expects to charge roughly $3 to $4 per gallon to incinerate PCB oil.[52]

Social Costs of Illegal Disposal--

Natural resource damage--The North Carolina Wildlife Resources Commission detected up to 12 ppm PCBs in mourning doves collected from areas contaminated with PCB oil; up to 0.92 ppm of PCBs were found in a control group of mourning doves taken from a county where no PCBs had been dumped. Up to 4.8 ppm PCBs were found in rabbits taken near the PCB spills; no PCBs were detected in controls.[53]

The U.S. Food and Drug Administration has set no tolerances for PCBs in game. The closest tolerance is that for poultry; it allows 3.0 ppm PCB in poultry fat. The Wildlife Resources Commission tested for PCBs on a wet weight basis. The Commission attempted to convert their measurements to a fat basis; in doing so, they found that doves were contaminated with up to 480 ppm of PCBs, or 160 times the FDA tolerance for PCBs in poultry.[54]

However, Dr. Renate Kimbrough of the Center for Disease Control believes that the Commission improperly analyzed the data. She feels that people eating game having the detected levels of PCB contamination would not exceed the FDA's safe daily intake standard for PCB. She also feels that the Commission did not analyze enough control specimens to determine what the "background" level of PCB contamination is.[55]

Property damage--Some garden and agricultural produce was destroyed or not harvested as a result of the PCB spills. North Carolina officials have not estimated the extent of the damages or monetized them, but note that damages were limited to garden produce, some commercial vegetable production, and some corn grown for silage. There was no loss in milk production.

The milk of dairy cattle grazing near contaminated areas was found in August 1978 to be contaminated with PCBs in concentrations as high as 0.214 parts per million (ppm). This, however, is significantly lower than the current federal tolerance of 1.5 ppm PCB (fat basis) in milk.[56] Some dairy herds near contaminated areas were monitored for a year after the spill; over that time the PCB contamination has dwindled to near trace amounts. Vegetables growing near the contamination were tested and found to have low levels of PCB contamination ranging up to 0.652 ppm. There are no federal tolerances for PCB contamination in vegetables. The contamination found in the vegetables is not considered dangerous.[57]

There is no evidence of a decline in property values along the spill routes, and no PCBs have been found in domestic wells in the affected areas.[58]

Acute and latent health effects--Immediately after the dumping, persons near the spills complained of nausea, headaches, and burning sensations in the throat and nose. Since PCBs are relatively non-volatile, these effects are attributed to the chlorinated benzene solvents present in the dumped PCB mixture. Chlorinated benzenes harm the endocrine and nervous systems, the liver, heart, and lungs.[59] Residents along the spill routes have reported births of congenitally malformed children, dog fetuses aborting, sick cattle, and headaches. These reports have been investigated by the North Carolina Division of Health Services, but so far no causal link or statistical correlation with the PCB spill has been found.[60]

Although it is difficult to assess the degree to which humans have been exposed to the dumped PCBs, or will be exposed in the future, latent health effects as a result of the spills must be considered a real possibility. The medical and scientific communities have reached the conclusion that PCBs are very hazardous. Their potential latent medical effects include cancer, birth defects, mutagenicity, and changes in behavior.[61] Reassuringly, a series of blood samples taken from persons living along the spill route have found no significant accumulation of PCBs in the blood.[62]

Enforcement and litigation costs--No estimate has been made of what it cost the state of North Carolina and the federal government to apprehend, indict, and try the Burnses and the Wards, nor of legal costs for the class action suit seeking cleanup and compensation.

Cleanup costs--The cost of the immediate response to the PCB spills--including analysis of the spilled material, surveying the extent of the pollution, covering the contaminated soil with carbon and asphalt, investigating possible agricultural and health effects, notifying the public, and general administrative costs--has not been estimated.

The state of North Carolina estimates that it will cost $1,580,000 to remove the contaminated soil from the road shoulders, reshape the shoulders, haul the contaminate material to the disposal site, and construct the disposal site.[63]

Cost Redistribution--

So far there has been no redistribution of social and private costs. However, in June 1981 the State of North Carolina filed suit against Ward and Burns seeking to recover approximately $12 million in damage and punitive costs. This suit, if successful, could substantially redistribute social of private costs.

Private Costs of Siting Hazardous Waste Facilities--

So far there have been no expenditures by private parties on behalf of siting the landfill. All the private expenditures have been made in an attempt to keep the landfill from being sited, first in Chatham County, then in Warren County. These expenditures include appearing at public hearings, writting to government officials and representatives, and, for the landowners near the proposed Warren County site, legal fees. The amount of these expenditures has not been estimated.

Social Costs of Siting Hazardous Waste Facilities--

The Costs of Having a Site (Regional)--

Natural resource damage--According to the draft Environmental Impact Statement prepared by the state of North Carolina, the proposed Warren County landfill will not adversely affect air or water quality, plant or animal life, or historical or archaeological resources. The only adverse environmental effect the state identified was the removal from agricultural production of the five acres used for the landfill.[64]

Property damage--Landowners adjacent to the proposed Warren County landfill allege that the landfill would constitute a private nuisance, impairing the enjoyment of their property, and lowering its value.[65]

Acute and latent health effects--According to the state's draft Environmental Impact Statement, the landfill will have no adverse health effects on workers or area residents.[66]

The cost of refusing the site--In its draft Environmental Impact Statement, the state says that the Warren County site is the best of the six most suitable disposal sites that have been identified. Another one of these six sites could presumably be used instead of the Warren County site, but at a higher total cost. Since the other five sites are not far from Warren County or the PCB contamination, using one of them would not impose greater removal, transportation, or disposal costs. However, the state would be forced to bear the cost of duplicating site evaluation, applying for an EPA permit, and gaining official and public approval for any new site, and this cost could be considerable. In addition, the other suitable sites are either closer to populated areas or have less favorable hydrologic characteristics,[67] which could increase the chance that the landfill would adversely affect natural resources or public health and safety.

Other alternatives avilable would be to: 1) Transport the contaminated material to an existing EPA-approved chemical waste landfill in Alabama; it is estimated that this would cost $12 million[68] 2) Incinerate the contaminated soil. The cost of this alternative has not been estimated, but it would surely be more than the $12 million estimated for disposing of the material in Alabama, since the material would have to be transported even further to reach an incinerator, and incineration is much costlier than landfilling. It should also be noted that so far EPA has not approved any PCB incinerators, although applications for two incinerators are pending. 3) Treat the waste in situ. This is not permitted by federal regulation, so North Carolina would have to bear the additional cost of a legal battle with the federal government and possible penalties. In addition, the in situ treatment may not protect the environment and public health and safety as well as removal and disposal of the material would.

Government expenditures to site facilities--The state of North Carolina has spent a substantial but uncalculated amount of money to identify and investigate possible disposal sites, seek approval from EPA, local officials and residents, and defend itself against the lawsuits seeking to prohibit use of the Warren County site. EPA and its counsel, the Department of Justice, have also had to pay an unknown amount to defend the federal government against the Warren County suits.

Footnotes

1. State of North Carolina, Removal and disposal of soils contaminated with PCBs along highway shoulders in North Carolina (Draft Environmental Impact Statement, December 28, 1979), p. 1.

2. Ibid.

3. Ibid.

4. *Ibid*., p. 2.

5. *Ibid*.

6. *Ibid*.

7. *Ibid*., p. 3.

8. *Ibid*., p. 1.

9. *Ibid*.

10. U.S. Environmental Protection Agency, *Studies conducted in connection with PCB spills in North Carolina* (November 9, 1978), p. 38.

11. *Supra*, note 1, p. 2.

12. David Hershman, *The Dumping of PCBs on North Carolina Highways*, Integrated Case Studies Program, Duke University (draft; paper in press), p. 5.

13. *Supra*, note 1, pp. 3-4.

14. Interview with Dr. Martin Hines, Chief of Epidemiology, North Carolina Department of Human Resources (May 28, 1980).

15. Interview with Leonard Blanton, Deputy Director, North Carolina Food and Drug Protection Division (May 12, 1980); Interview with Dr. William Cobb, Director, North Carolina Food and Drug Protection Division (May 28, 1980).

16. *Ibid*.

17. *Supra*, note 1, p. 9; *supra*, note 11, p. 5.

18. *See* State of North Carolina v. Robert Burns, Indictment, August 28, 1978.

19. Marc Leepson, "The Waste That Wouldn't Go Away," *Environmental Action* 10:11 (October 7, 1978), p. 4.

20. Interview with Donald Stevens, North Carolina Department of Justice (May 12, 1980).

21. 15 U.S.C. §§2601-2629.

22. *Ibid*., §2615.

23. Interview with Ralph W. Jenning, EPA Region IV (October 21, 1981).

24. Interview with Donald Moore, Sales Manager, Ward Transformer Company (May 13, 1980).

25. *See* State of North Carolina v. Robert Earl "Buck" Ward Jr., Indictment, January 22, 1979.

26. *Supra*, note 20.

27. *Supra*, note 23.

28. *Ibid*.

29. N.C.G.S. §14-284.2 (1979).

30. *Supra*, note 1, pp. 4, 10-11.

31. *Supra*, note 12, pp. 11-12.

32. *Supra*, note 1, pp. 25-26.

33. Interview with David Kelly, North Carolina Department of Crime Control and Public Safety (May 23, 1980).

34. *Supra*, note 12, p. 12.

35. Application to EPA (December 12, 1980).

36. Resolution of Warren County Board of Commissioners (January 2, 1979).

37. Resolution of Vance County Board of Commissioners (April 2, 1979).

38. Letter from John C. White, Region IV EPA Administrator, to North Carolina Governor James B. Hunt (June 4, 1979).

39. *Supra*, note 12, pp. 13-14.

40. *Supra*, note 33.

41. Warren County v. North Carolina et al, No. 79 CVS 167 (Warren Cty. Sup. Ct., filed August 16, 1979).

42. *Ibid*., Temporary restraining order (August 16, 1979).

43. Warren County, An ordinance prohibiting the storage and disposal of PCBs (August 21, 1979).

44. *Supra*, note 41, preliminary injunction (September 6, 1979).

45. Twitty, et al. v. State of North Carolina No. 79-CO8-183 (Warren Cty. Sup. Ct., filed September 12, 1979).

46. Interview with Charles Johnston, Warren County Attorney (May 28, 1980); Interview with Lewis A. Thompson III, attorney for Twitty et al. (May 28, 1980).

47. Langdon v. Hunt, No. 80-487-CIV-5 (E.D. North Carolina, July 7, 1980).

48. *Supra*, note 20.

49. 43 Fed. Reg. 7150-7164 (February 17, 1978).

50. Interview with William Gunter, PCB regulation team leader, EPA (May 12, 1980).

51. Interview with Gary Odom, Holley Electric Company (May 13, 1980).

52. Interview with William Stevens, Rollins Environmental Services (May 12, 1980).

53. Memorandum from Carl W. Betsill, Wildlife Biologist, North Carolina Wildlife Resources Commission to Grady Barnes, Assistant Chief, Division of Game, North Carolina Wildlife Resources Commission (January 25, 1979).

54. *Ibid*.

55. Interview with Dr. Renate Kimbrough (June 23, 1980).

56. 32 C.F.R. §109.30(a)(1).

57. *Supra*, note 15.

58. *Supra*, note 33.

59. Coate, W.B., Schoenfisch, W.H., Lewis T.R., Busey, W.M. 1977. Chronic inhalation exposure of rats, rabbits and monkeys to 1,2,4-trichlorobenzene. *Arch. Environ. Health* 32(6):249-255.

Fomenko, V.N. 1965. Determination of the maximum permissible concentration of tetrachlorobenzene in water basins. *Hyg. Sanit.* (USSR). 30:8-15.

Rimington, C., and Ziegler, G. 1963. Experimental porphyria in rats induced by chlorinated benzenes. *Biochem. Pharm.* 12:1387-1397.

60. *Supra*, note 14.

61. *See*, generally, 42 Fed. Reg. 6532 *et seq*. (February 2, 1977); National Institute for Occupational Safety and Health, *Criteria for a recommended standard. Occupational exposure to polychlorinated biphenyls (PCBs)*. Washington: December 1977.

62. *Supra*, note 14.

63. *Supra*, note 1, p. 9.

64. *Ibid*., pp. 34-37.

65. *Supra*, note 45.

66. *Supra*, note 1, p. 36.

67. *Ibid*., pp. 23-24.

68. *Ibid*., p. 36.

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GENUINE RISK: KENTUCKY'S VALLEY OF THE DRUMS

Introduction

On a ten-acre site near Brooks, Kentucky, Arthur L. Taylor stored and dumped the drums of chemical wastes that he hauled away from Louisville industries. Eventually thousands of drums, some empty, some full and oozing waste, littered Taylor's dump, giving the site its popular name: The Valley of the Drums. The Valley of the Drums became an abandoned waste dump in 1978 when Arthur Taylor died, leaving a small estate inadequate to pay for the massive efforts needed to clean up the site.

Although Kentucky environmental officials had known of Taylor's operation since 1967, the state did not take action to close and clean up the site until January 1979. In March 1979, the U.S. Environmental Protection Agency joined the cleanup efforts prompted by reports that oil and other chemicals from the site were entering nearby Wilson Creek. EPA spent $300,000 of emergency clean up funds to sort and stack the drums of waste and divert runoff from the site through a treatment plant before it enters Wilson Creek.

EPA counted 17,051 drums on the surface of the dump. Of these 11,628 were empty, 3,239 contained solid wastes and the remaining 2,184 contained liquids. An unknown number of drums lie buried in the dump and a substantial amount of earth has been contaminated by wastes that Taylor poured directly into pits. In soil and water samples taken in and around the dump, EPA has detected 197 organic chemicals and 28 metals, including 21 suspected carcinogens, mutagens, and teratogens and 26 priority water pollutants.

EPA's cleanup was only a stop-gap aimed at preventing runoff into Wilson Creek; the Agency was initially restricted to such measures because use of the emergency funding used to pay for the cleanup was limited to abating immediate threats to navigable waters.

By the Summer of 1980 Kentucky had managed to persuade five of the largest generators of the waste dumped at the Taylor site to remove the filled drums that could be identified as having originated with them. This action took care of 1,300 of the filled drums. With the passage of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) the state has received $400,000 and all the liquid waste at the site has been removed. As of October 1980, officials are planning to conduct a feasibility study to assess the cost of total cleanup.

Background Information

The Location--

The Valley of the Drums is located in a rural area in Bullitt County, Kentucky, fifteen miles south of Louisville. (See Figure B-4.) Fortunately, the site is well suited geologically for service as a waste dump, being made up of relatively impermeable shale and clay that prevents surface water from percolating down to groundwater. In fact, a Kentucky state geologist reported that "the site would be excellent for the disposal of hazardous waste by incineration or chemical treatment and with proper engineering would be technically sound for burial also."[1]

Waste Disposal--

From 1967 until his death in February 1978, Arthur Taylor hauled drummed chemical wastes from manufacturers in Louisville. According to the generators of the waste, Taylor assured them he was hauling these wastes to approved landfills and incinerators.[2] Taylor did haul some of the waste to the nearby Smith landfill, but much of it he brought to his property in Bullitt County near Brooks, Kentucky. Here Taylor disposed of the wastes by pouring them into pits in the ground or nearby Wilson Creek, burying them in drums on the property, or burning them in open fires. Taylor cleaned and stored the drums he had emptied on the site until he eventually resold them to drum recyclers.

Later investigations have found that Taylor hauled waste primarily for five generators: Reliance Universal, a paint and coatings manufacturing company; Ford Motor Company, which has an automobile assembly plant near Louisville; the George W. Whitesides Company, a solvent recycler; Kurfees Coatings, which manufactures paints and coatings; and Louisville Varnish, another coatings manufacturer. Analyses have shown the wastes in the Valley to be predominantly paints, pigments, solvents used in the paint industry, and plastics.[3]

Taylor charged up to $2.50 per drum to remove waste.[4] This fee apparently covered in most cases both hauling and disposal of the waste at his dump. Reliance Universal, however, reports that it paid Taylor $2.50 per drum to haul the waste to the Smith Landfill near the Valley of the Drums, and paid Taylor an additional $3.00 per drum to cover disposal at the landfill. Reliance eventually discovered that Taylor was not delivering all its waste to the landfill and was apparently pocketing the landfill charge. Reliance then began to pay the landfill separately for waste that Taylor hauled there.[5]

Another waste generator, Ford Motor Company, reports that it chose Taylor as it did other waste haulers, by seeking

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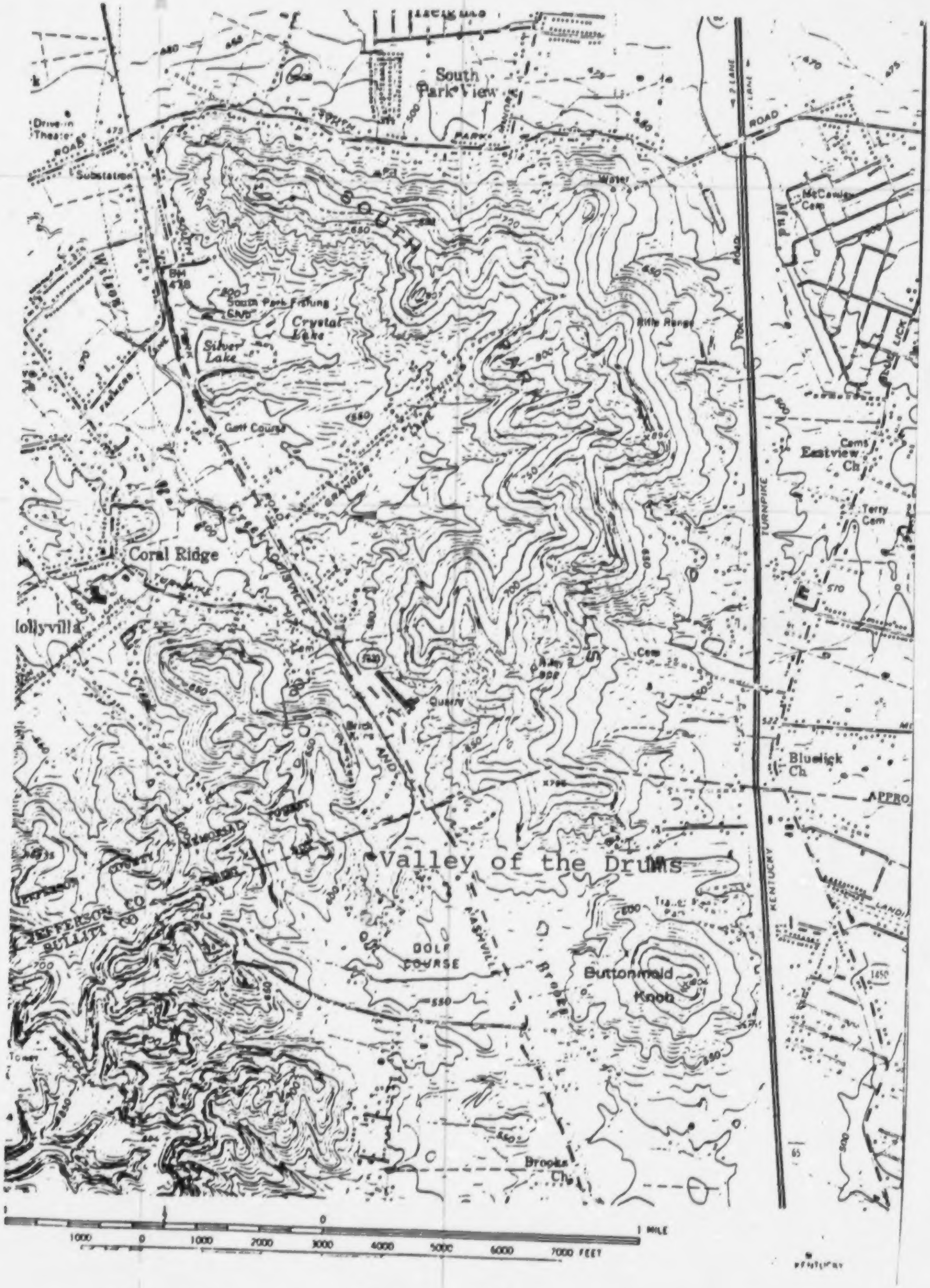
South Park View
Drive-in Theater
Substation
SOUTH PARK
South Park Fishing Lake
Crystal Lake
Silver Lake
Golf Course
Rifle Range
Eastview Ch
Terry Cem
Coral Ridge
Quarry
Bluelick Ch
Valley of the Drums
JEFFERSON CO
BULLITT CO
GOLF COURSE
Buttonmold Knob
Brooks Ch
KENTUCKY TURNPIKE
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Figure B-4. Location of the Valley of the Drums.

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competitive bids. Ford required Taylor, like other waste haulers, to sign an agreement stating that the wastes hauled from Ford would be disposed of in a legal manner.[6]

Records of the generators from which Taylor hauled waste indicate that he hauled at least 27,389 drums during the eleven years he was in business.[7] In March 1979, 17,051 drums were counted on the surface of the site; the remaining 10,000 or more drums are presumed to have been buried at the site, disposed of elsewhere, or emptied at the site and resold to recyclers.[8]

Taylor's operation was a small one, consisting of just himself and a few occasional employees and a couple of trucks. Taylor did not have the required permits for hauling hazardous waste or for using his property as a disposal site.[9]

Response--

State enforcement action--Kentucky state environmental officials knew of Taylor's operation since 1967, but even though he was operating illegally, the state took no action to close his dump until 1979.

The first state contact with the site came on December 13, 1967, when the solid waste and air pollution control programs of the Department of Natural Resources and Environmental Protection jointly investigated reports of open burning at the Taylor dump. Officials gave Taylor information on operating a sanitary landfill. When they returned a year later, state investigators found open burning continuing to take place, but took no enforcement action.[10]

The state next became involved with the Taylor dump in November 1975 when the Division of Water Quality of the Kentucky Department for Natural Resources and Environmental Protection (DNREP) inspected the site in response to complaints from neighboring landowners. Joseph Vanhoozer, who at the time owned land abutting Wilson Creek just downstream from the Valley reports that the vapors coming from wastes dumped into Wilson Creek were overpowering at times, and that pigs he kept on this property once became covered with red paint after they had wallowed in the creek.[11] Another neighboring landowner, Jelline Bolt Owen, had to move a horse from her property because of the wastes in Wilson Creek.[12] Mr. Vanhoozer and Ms. Owen complained to various governmental authorities about the pollution, including the local fire and health departments[13] in addition to the Water Quality Division.

A Water Quality Division inspector sent to the site in response to the complaints took samples from Wilson Creek, but noted that there was no need to test them because they were almost pure oil and paint.[14] As a result of this and other inspections, the Division filed an administrative complaint against Taylor in early 1976, which charged him with violations of water pollution control law, including discharges of paint, oil, and other industrial wastes to Wilson Creek; failure to obtain a permit for the discharges; and failure to report spills.[15] On April 23, 1976, a hearing was held on the administrative complaint at which the Division presented its case against Taylor. Ms. Owen testified that the pollution in Wilson Creek was sometimes so thick that one could walk on it.[16] Taylor did not appear at the hearing to present a defense, nor did he send a representative, although he had been notified of the hearing.[17]

After this hearing, the enforcement system apparently broke down. Testimony indicated that Taylor was violating the law, but the hearing officer presiding over the case did not file a report indicating how the case should be resolved until August 1978, over two years later. The hearing officer said that he took so long in issuing a report because he had forgotten about the case.[18] Apparently the Division of Water Quality did not press him to issue a report. The "recommended order" he finally filed in August 1978 recommended that the site be closed and that Taylor's estate--Taylor died in February 1978--be fined $3,000. The order was never implemented, however, because the Secretary of the Department for Natural Resources and Environmental Protection declined to sign it, feeling that the case was "too bollixed up" to enforce the order after the delays.[19]

In May 1977, the Division of Hazardous Material and Waste Management of DNREP began to investigate the Valley of the Drums. During one of several visits to the site in May 1977, inspectors discovered Taylor digging a trench for the burial of drums. Taylor was told that he must have a permit to operate a disposal site. Taylor agreed to cease operations and apply for a permit. Taylor went to Frankfort, the state capital, on May 25, 1977 to discuss obtaining a permit, but never filed an application for one. Although an inspection on June 7, 1977 found no activity at the Valley, by October 1977 there was evidence that Taylor had resumed burying drums, still without a permit. The Division warned Taylor on November 14, 1977 that he was operating in violation of the law. The next day he requested another permit application form. Further inspections in late November 1977 revealed that Taylor had buried more waste on the site, so on November 30, 1977, the Division asked DNREP's Office of General Counsel to take legal action to stop the disposal and clean up the site.[20] Inexplicably, the Office of General Counsel never brought charges against Taylor and the Division of Hazardous Materials and Waste Management did not pursue the matter.

DNREP finally took action to close and clean up the site in January 1979, nearly a year after Taylor's death. On January 12, 1979 the Department took samples of drum contents and surface water on the site. Analysis revealed wastes typical of the paint industry, including such solvents as methyl ethyl ketone, toluene, ethyl benzene, butyl alcohol, and xylene. No pesticides or PCBs were detected at this time.[21] On January 22, 1979, EPA and the state Division of Sanitary Engineering surveyed the houses within a one-mile radius of the dump and found only two with wells. All other houses were served by the Louisville Water Company or by cisterns.[22]

One of these houses was found to have low concentrations of such organics as chloroform, bromodichloromethane, xylene, and diethylphthalate in its well water. Apparently the concentrations were not considered high enough to warrant changing water supplies. At the other house no organic compounds in concentrations greater than 5 micrograms per liter (equivalent to 5 ppm) were found.[23]

DNREP initiated legal action on January 22, 1979, when it filed an administrative complaint against Nell Taylor, Arthur Taylor's widow, alleging that she was transporting and disposing of hazardous waste without a permit, operating a solid waste disposal site without a permit, and discharged pollutants into Wilson Creek. DNREP asked that Mrs. Taylor be enjoined from future activities in violation of the law, be required to clean up the site, and be assessed civil penalties of $31,000 per day.[24]

A hearing was held on DNREP's complaint March 27, 1979, and on March 29, 1979, the presiding hearing officer filed an interim report. DNREP presented its case at this hearing, but since Mrs. Taylor did not present a case other than by cross-examination of DNREP's witnesses, the hearing officer's report stated only the undisputed facts in the case. It did not conclusively adjudicate the case nor did it consider whether to impose penalties on Mrs. Taylor.[25] DNREP's complaint against Mrs. Taylor has lain dormant since March 1979 because the Department has chosen to take other non-legal measures to try to clean up the Valley.

Grand Jury investigation--The Bullitt County Grand Jury, at the request of Circuit Court Judge C.V. Sanders, investigated dumping at the Taylor site during its February 1979 term. On March 5, 1979, the Grand Jury reported that it could find "no evidence of criminal conduct on the part of those manufacturers whose waste by-products have been stored in Bullitt County." After further investigations during its April and December 1979 terms, the Grand Jury broadened this finding, stating that "under the laws in existence at the time hazardous wastes were disposed of on the site, no indictable offenses had been committed."[26] The Grand Jury, of course, only addressed itself to criminal offenses, and did not consider civil liability.

Emergency cleanup--On March 2, 1979, the U.S. Environmental Protection Agency began emergency cleanup operations under §311 of the Federal Water Pollution Control Act,[27] which authorizes the cleaning up of discharges of oil and hazardous substances to navigable waters. DNREP requested the emergency aid after finding that oil and chemicals from the site were being washed into Wilson Creek.

To contain contaminated runoff from the site, EPA's contractor dug ditches to divert surface water to a catchment pond, where a filtration unit was installed to purify discharge from the pond before it entered Wilson Creek. In addition, an underflow dam and aeration units were installed in Wilson Creek. These measures achieved a 98% reduction in pollutants leaving the site.[28]

The contractor next sorted and stacked drums according to their contents. As of March 21, 1979, there were estimated to be 17,051 drums on the surface of the Taylor dump, of which 11,628 were empty. Of the full drums, 3,239 contained solids, and 2,184 contained liquids. The empty drums, except for a few suitable for resale, were crushed and stacked on the site. In addition, an unknown number of drums are buried at the site and an unknown amount of soil has been contaminated with chemical wastes.[29]

EPA was unable to have the drums removed from the site and properly disposed of because §311 of the FWPCA only authorizes expenditures to abate immediate threats to navigable waters. With the catchment and filtration system installed on site, that goal had been achieved. The state and EPA both claim to not have the money needed to clean up the site permanently and dispose properly of the waste there.

During the cleanup, EPA took numerous soil and water samples within and around the site. Analysis found 126 organic compounds in standing water and runoff from the site. These were mostly solvents, ketones, pthalates and other organic compounds associated with the paint and plastics industries. No PCBs were detected in any of the water from the site. Tests of sediments from several drainage areas on the site showed a large number of organic compounds, along with lead, zinc and titanium. PCBs in concentrations of up to 14 ppm were found in sediment from three sampling sites.[30] The only chlorinated pesticide found was 1.7 ug/l of 1,2,4-trichlorobenzene in one of the samples.

Water samples from Wilson Creek had approximately the same range of organic compounds as those found in runoff from the site. No PCBs were found in the water in Wilson Creek, but up to 3 ppm of PCBs were found in sediment from the creek bed.[31]

EPA analyzed fish and crayfish from Wilson Creek near the Valley of the Drums and further down the drainage for chlordane and PCBs. The fish sample taken nearest the Valley of the Drums had no detectable concentrations of either of the substances. Other fish in the drainage had up to 2.97 ppm of chlordane, and 0.48 ppm of PCBs.[32] The FDA tolerance for PCBs in the edible portion of fish at the time of the sampling was 5 ppm; since August 1979 it has been set at 2 ppm.[33] The PCBs detected thus far were below the FDA tolerances, but on March 21, 1979, Eugene Mooney, Secretary of DNREP, advised against eating fish from Wilson Creek.[34] It is unclear whether the chlordane found in the fish originated at the Valley of the Drums. One EPA scientist believes that the source of the chlordane more likely is termite treatment of houses in the area.[35]

Of 142 compounds identified in the water and soil on and near the site, 40 are included in the Human Effects Section of the Registry of Toxic Effects, 27 are in the Carcinogenic Effects Section, and 6 are in the Teratogenic Effects Section.[36]

The cleanup cost roughly $300,000 and the analyses of soil and water cost approximately $200,000.[37]

EPA's cleanup of the site has only a temporary solution, which the head of the Emergency Response Branch of EPA's Region IV characterized as a "band-aid" designed to last six to eight months. According to the EPA engineer who designed the system, the site's water filtration plant requires a rejuvenation costing around $20,000 every six months. EPA recharged the system's filter and cleared out the diversion tranches in July 1979 at a cost of $28,000; since then maintenance of the plant has been the state's responsibility.[38] The state is about to clean and recharge the filtration system again; it estimates that this will cost $10,000.[39]

Comprehensive cleanup--Because of the limitations of §311 of the Federal Water Pollution Control Act, the State of Kentucky had to look to other sources for a complete cleanup of the site that would go beyond the containment achieved in March 1979. A complete cleanup will be expensive. State officials estimate that it will cost roughly $2.5 million to analyze, remove, and properly dispose of the wastes dumped at the Valley of the Drums.[40] Because Taylor's widow, who inherited the site from Taylor, had only limited resources,

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the state has not pursued its complaint against her. If the state obtained a judgment against her, she would in all probability declare bankruptcy, leaving the state with the property and the responsibility for cleaning it up. Instead, the state decided to try to get the generators of the waste to clean up the site.

The state at first considered an innovative approach to cleaning up the site proposed by William Fluhr. Fluhr wanted to buy the dump site and operate on it a model chemical waste disposal center, including a liquid waste incinerator, a solvent recycling facility, and a barrel cleaning service. Once in operation on this site, Fluhr would have incinerated or recycled the wastes dumped on the site.[41] Fluhr and Mrs. Taylor are reported to have agreed on a price of $30,000 for the 25-acre site.[42] However, the current agriculture zoning of the property would not permit operation of the waste facility, and the community objected to any zoning change, thereby scuttling the plan.

The state next turned to the generators of the waste dumped at the site. Rather than sue the generators to force a cleanup, however, the state had decided to pursue a voluntary effort. The state has managed to persuade the five firms that generated most of the waste dumped at the Valley of the Drums to pick up and properly dispose of the wastes that they can identify as having originated with them. The companies that have agreed to do this are the Ford Motor Company, Reliance Universal, Louisville Varnish, Kurfees Coatings, and the George Whitesides Company.

Because drums are often recycled and because Taylor himself emptied and refilled drums, it is very difficult to positively identify markings on the outside of drums, as they do not necessarily indicate the source of the drums' contents. This makes it difficult to positively identify the origin of the wastes at the Valley of the Drums. As a result, the five companies have claimed only around 1,300 of the 5,423 full drums on the site.[43] For example, Reliance Universal, whose records indicate that Taylor hauled 13,301 drums of its waste,[44] picked up only 950 drums of waste.[45] Ford Motor Company records show that Taylor hauled 10,105 drums of its waste;[46] it is picking up just 338 drums from the site.[47]

Reliance Universal, the first of the five companies to remove its waste, picked up 950 drums it had identified in May and June 1980. Reliance will dispose of the liquid waste it removes from the site at an incinerator in Kentucky. Solid wastes will be disposed of at a secure chemical landfill in Ohio, as there are no approved hazardous waste landfills in the state of Kentucky.[48]

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Reliance estimated that it would cost approximately $65 per drum to remove and dispose of 950 drums of waste from the site,[49] or around $62,000 altogether. This corresponds roughly with cost figures supplied by Ford, which estimates that it will cost approximately $50 per drum to test, remove and dispose of the 338 drums of waste it has identified at the Valley of the Drums.[50] If Reliance's figure is correct, it will cost the five waste generators approximately $85,000 altogether to remove and dispose of the 1,300 drums of waste that they have agreed to pick up from the site.

In September of 1981, the State received $400,000 from the Environmental Protection Agency under the Comprehensive Environmental Response, Compensation and Liability Act of 1980. These funds have been used to remove the remaining 4,000 full drums of liquid waste and to upgrade surface water treatment at the site. The Kentucky Bureau of Environmental Protection plans to conduct a feasibility study in the near future to assess the extent of underground damage and the associated cost of remedial action.[51]

Costs

Private Costs of Waste Disposal--

Actual cost of illegal disposal--Taylor charged up to $2.50 per drum to dispose of waste. At least one waste generator, Reliance Universal, paid Taylor an additional $3.00 per drum to cover disposal fees at a nearby landfill. However, Taylor apparently failed to deliver the waste to the landfill and simply pocketed the additional money.

Comparative cost of proper disposal--Proper disposal of the wastes found at the Valley of the Drums would have cost between $15 and $25 per drum in 1976.[52]

The Social Cost of an Abandoned Site--

Natural resource damage--Because of the low permeability of theclay soil at the Valley of the Drums, groundwater appears not to have been contaminated by the wastes dumped there. Wastes from the Valley of the Drums may be responsible for the low level of organic contamination found in one drinking water well near the site. Taylor's direct dumping into Wilson Creek and runoff from the site polluted that creek, which empties into the Ohio River. The effects of the pollution have not been quantified. Fish and crayfish in Wilson Creek are contaminated with low levels of PCBs and chlordane.

The chlordane contamination cannot be definitely tied to the Valley of the Drums, but the PCB contamination probably can be. Although the concentrations found thus far are below FDA tolerances for PCB contamination in fish, the state of Kentucky has advised against fishing in Wilson Creek. This has caused a loss in recreational resources.

Property damage--Presumably Mrs. Taylor's land is worth far less than it would be if waste had not been disposed of there. Her exact losses are hard to determine, however. As of January 1, 1978, Bullitt County Property Tax Rolls indicated that Taylor owned real property worth $10,000; apparently this was the dump site.[53] However, Fluhr was reported to have been willing to pay three times that amount in 1979 for the property if he could get rezoned to accommodate a waste disposal operation. Without the rezoning, Fluhr was not interested in the property. Mrs. Taylor is reported to be continuing to try to sell the dump site.[54] Since she has not yet met with success, the value of the property may be quite low.

Joseph Vanhoozer last year sold property he owned on Wilson Creek downstream from the Valley of the Drums. He felt that the property was worth $14,000. Many people inquired about the property, but most lost interest after hearing that it was near the Valley of the Drums. Vanhoozer finally sold the property for $8,000.[55] Other property owners near the Valley of the Drums would probably suffer similar losses if they tried to sell their property.

Acute and latent health effects--No acute health effects have been reported. It is possible that chemicals in the runoff from the site may cause latent health effects if they enter drinking water via Wilson Creek and the Ohio River or are taken up by fish that are later consumed by humans. Seventy-three of the contaminants found at the site are listed in the Registry of Toxic Effects, indicating possible health dangers.

Enforcement and litigation costs--The state of Kentucky calculates that it had spent $24,391.12 in connection with the Valley of the Drums as of October 3, 1979, excluding overhead. Part of this sum went for enforcement and part went for supervising and arranging cleanup. This expenditure was for both enforcement of waste and disposal laws and regulations and for supervising cleanup; how much went to each of these categores has not been calculated.

Bullitt County, Kentucky, spent an undetermined amount for the three grand juries that investigated the Valley of the Drums.

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Since no private parties have filed suit against Taylor or his estate, no private ligitation costs have been incurred in connection with this case.

Cleanup costs--EPA has spent $328,000 to clean up the site and recharge the filtration system once, $200,000 for analysis of soil and water samples. In September of 1981, EPA designated an additional $400,000 from Superfund to remove liquid wastes and upgrade surface water treatment.

An undetermined amount of the $24,391.12 spent by the state of Kentucy in connection with the Valley of the Drums as of October 3, 1979 went to arranging and supervising cleanup. The state also expects to spend $10,000 to clean and recharge the filtration system on the site.

The five major generators of waste at the site will spend approximately $85,000 to remove 1,300 drums of waste from the site. $2.0 million or more will still have to be expended before the Valley of the Drums is cleaned up for good.

Redistribution of Costs--

All indications are that Taylor is at fault for the pollution. He therefore should be the one to pay, but he is dead, his business is defunct, and his estate does not have the resources to pay for a cleanup. The state could sue his widow, but if it did she probably would declare bankruptcy, leaving the state with the property and the responsibility for cleaning it up.

The generators of the waste dumped at the Valley of the Drums likely reaped economic benefits from Taylor's waste disposal operation, so it might be argued that they are morally if not legally liable for bearing some of the cleanup costs. The hypothetical generators' benefits stem from the presumption that the fees Taylor charged were lower than what it would have cost to properly dispose of the wastes. Since paying the full cost of proper waste disposal should be seen as one of the costs of doing business, the generators in effect received a discount on their waste disposal costs. Some of the generators are paying back at least part of what they gained from lower-cost improper waste disposal by picking up wastes they can identify as having originated with them.

In the end, however, it appears that the cost of cleaning up the Valley of the Drums will be borne by the public at large. Both the state and federal government will probably end up paying for the total cleanup, using either general revenues or the Superfund which is financed by a tax on chemical feedstocks which will ultimately be paid by consumers.

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Footnotes

1. Memorandum from Hussein Aldis to John T. Smither, Director of Division of Hazardous Material and Waste Management (March 16, 1979).

2. Interview with William Christoph, Managing Engineer, Louisville Assembly Plant, Ford Motor Company (June 10, 1980); Interview with Paul Brooks, Reliance Universal International (June 10, 1980).

3. Interview with Jack Wilson, Commissioner, Kentucky Bureau of Environmental Protection (June 10, 1980).

4. Interview with Jack Wilson (July 8, 1980); Interview with Paul Brooks (July 9, 1980).

5. Interviews with Paul Brooks (June 10, 1980 and July 9, 1980).

6. Interview with William Christoph (June 10, 1980).

7. Interview with Royal Nadeau, Environmental Response Team, U.S. EPA (June 16, 1980).

8. Kentucky Department for Natural Resources and Environmental Protection (DNREP) *Historical Summary* [of Valley of the Drums] (no date).

9. *Supra*, note 3.

10. *Supra*, note 8.

11. Interview with Joseph Vanhoozer (June 12, 1980).

12. Jim Adams and Jim Detjen, "The barrels: a problem that just won't go away." [Louisville] *Courier-Journal* (January 17, 1979), p. E7.

13. *Supra*, note 11.

14. *Supra*, note 12.

15. *Ibid*.

16. *Ibid*.

17. *Supra*, note 8.

18. *Supra*, note 12.

19. *Ibid*.

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20. Supra, note 8; Jim Adams and Jim Detjen, "'Valley of Drums': Pleas for action went unheeded" [Louisville] Courier-Journal (February 4, 1979), p. E7.

21. Supra, note 8.

22. Ibid.

23. Kentucky DNREP, Briefing Summary (March 19, 1979).

24. Bureau of Environmental Protection v. Mrs. A.L. Taylor, File No. 1615-06 (Administrative Complaint before DNREP, filed January 22, 1979).

25. Ibid., Report and Recommendation of the Hearing Officer (March 29, 1979).

26. Reports, Bullitt County Grand Jury, February, April, and December Terms 1979.

27. 33 U.S.C. §1321.

28. Richard D. Stonebraker and Al J. Smith, Jr., "Containment and treatment of a mixed chemical discharge from the 'Valley of the Drums' near Louisville, Kentucky" (no date).

29. Supra, note 8.

30. Ibid., U.S. EPA, Louisville Hazardous Waste Site Briefing Summary (April 6, 1979).

31. Ibid.

32. Supra, note 7.

33. 21 C.F.R. §109.30.

34. DNREP, Press Release (March 21, 1979).

35. Supra, note 7.

36. Ibid.

37. "Needed: Hazardous waste disposal (but not in my back-yard)" 13 Environmental Science and Technology 914 (August 1979).

38. Interview with Al J. Smith, Jr., U.S. EPA (May 27, 1980).

39. Interview with Jack Wilson (July 9, 1980).

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40. *Supra*, note 3.

41. *Supra*, note 37.

42. Interview with Jack Wilson (June 11, 1980).

43. *Supra*, note 3.

44. *Supra*, note 7.

45. *Supra*, note 4.

46. *Supra*, note 7.

47. *Supra*, note 6.

48. *Supra*, note 45.

49. *Ibid*.

50. *Supra*, note 6.

51. Interview with Barry Burres, Kentucky Bureau of Environmental Protection (October 21, 1981).

52. Interview with Fred Schwartz, CECOS International (July 9, 1980).

53. Jim Adams and Jim Detjen "Opinions vary about 'Valley of Drums' Operator" [Louisville] *Courier-Journal* (January 23, 1979) p. E7.

54. *Supra*, note 3.

55. *Supra*, note 11.

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